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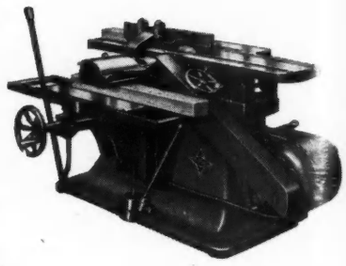

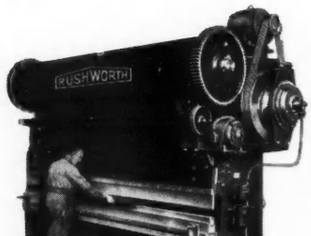


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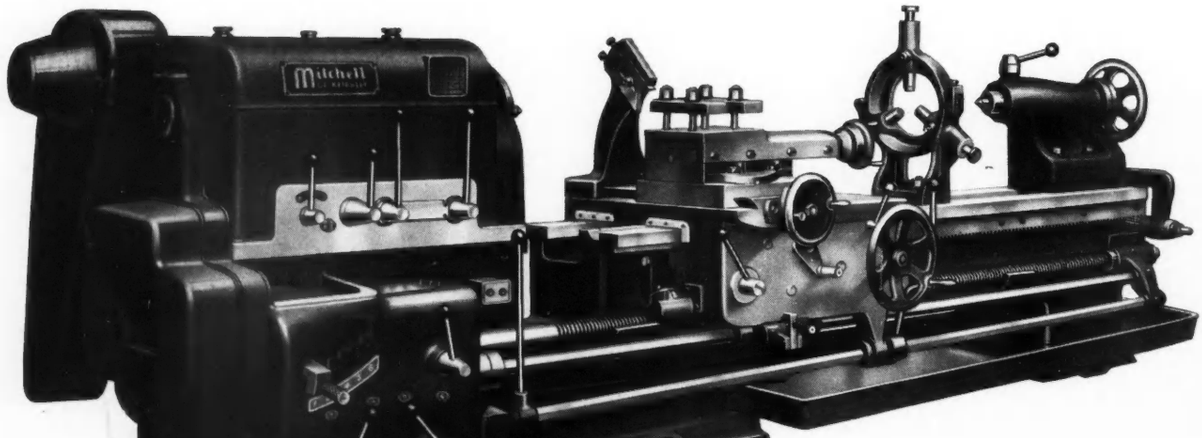


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# THE AIRLINES' PART

THE title of Sir Miles Thomas's lecture to the Institute of Transport, reported on another page, was "The Impact of the Gas Turbine on Civil Aviation." He would have been justified in using the reciprocal of that phrase – justified in speaking of "The Impact of Civil Aviation on the Gas Turbine" – for, as chairman of British Overseas Airways Corporation, he showed how greatly the airways corporations have enriched the development of aeronautical gas turbines in the past ten years. It was in 1944 that representatives of B.O.A.C. expressed to the Brabazon Committee their intention to support the introduction of gas-turbine engines. A year later they had "sufficient faith in the de Havilland Company to place a firm order for the D.H. 106, which was the factory name for the Comet." The benefit of that early and far-seeing decision is now being reaped because it required six years – from May, 1946, to May, 1952 – to pass from the final conception of the Comet on paper to the carrying of the first fare-paying passengers.

The quantity production methods to which American industry is tied – methods which are usually regarded as almost an unfair advantage, deriving from the large home market for most of their products—have not been an advantage in the early development of gas-turbine aircraft. While the American manufacturer, committed to the utmost tooling and preparation for quantity production, prefers to be sure of large sales before he embarks on his programme, the British manufacturer can, and does, go into production with a design which he knows he will improve almost before the first machine is turned out. He can do this, too, because "the degree of hand work, of sheer craftsmanship, in British aircraft is high" – to quote Sir Miles Thomas.

What is the principal factor in aircraft design policy? According to the chairman of B.O.A.C. it is the type of engine available. The de Havilland Ghost engine enabled the civil jet airliner to be introduced some three years earlier than would otherwise have been possible, and the lead is now being maintained because the lessons of the resultant operational experience are being embodied in later versions of the aircraft, designed to take the Avon engine, with its higher power and lower fuel consumption.

From the operator's point of view the engine is a critical factor for another reason – a financial reason. Gas-turbine power plants for aircraft cost up to £45,000 each. The scale of spare engines and parts must therefore be kept to a minimum; engines must be delivered quickly by air; operators must pool equipment; and every effort must be made to salvage the expensive materials used in the "hot" parts of the engine. The chairman of B.O.A.C. suggested that, just as some road operators buy tyres on a mileage basis, so airline operators might buy engines in terms of flying hours. Meanwhile, the British airways corporations are giving aircraft manufacturers the opportunity to prove their aircraft in service. Only in this way will it be possible to reach the stage where overseas operators are convinced by results. The Comet, the Viscount and the Britannia have attracted a fair volume of initial orders, but the volume is not yet sufficient to amortise the large tool charges which have been incurred. As soon as British jet aircraft have established themselves as reliable and profitable machines, and if this goal can be reached before American civil jet aircraft have reached the same stage, there will very likely be a flood of orders as hesitant operators abroad decide more or less simultaneously to take the plunge. Recent accidents with jet aircraft will then be seen in proper perspective, as significant, though costly, lessons in development, and the blinding glare of sensationalism will have died down.

So far, the British airways corporations have borne the brunt of the burden of development of British jet airliners in service. The organisation at airports must be recast to conform with the new operating characteristics. Transit stops must be reduced to a minimum, refuelling speeded up, passengers shepherded quickly but without appearance of hurry, luggage handled expeditiously, ground communications and booking services improved, aircraft servicing simplified, and international route communications and navigational aids brought up to date. These are difficult tasks for a pioneering airline working by itself and without the ready co-operation of overseas Governments and airlines, but if they are not tackled the advantages of the gas turbine will not be fully exploited and high operating costs will arise. Sir Miles Thomas's lecture was a revelation of how manufacturers and operators have had to dip into the future, "far as human eye could see." No wonder the chairman of B.O.A.C. is thinking that "in this year 1954 and possibly in 1955 we ought to take time out for meditation and free-thinking." British aircraft makers and operators will have nothing to fear if the men who ponder the problems of the next decade are as imaginative as those who have led the world since 1944. It is to be hoped they are.

# Weekly Survey

## PLANT-SCALE EXPERIMENTS IN STEELWORKS

When delivering his presidential address to the Sheffield Metallurgical Association on January 26, Mr. F. H. Saniter, director of research to the United Steel Companies, Limited, Sheffield, referred to plant-scale experimentation. This, he added, was a field inadequately covered in the past but which could be made to yield a rich harvest. He then outlined four examples of this type of work. The first related to the development of faster-melting open-hearth steel furnaces in the Templeborough melting shop, emphasis being laid on the influence of the design and instrumentation of the furnace and the materials used for its construction. The second example concerned the application of the more intense combustion of fuel oil to an experimental premelting apparatus designed to reduce the consumption of current and electrodes in electric steelmaking at the Samuel Fox Works, Stocksbridge. The third example dealt with the experimental operation of a pilot Rossi continuous-casting plant at the Barrow Steelworks. The main object of this is to cast 2-in. square billets continuously from liquid steel in order to eliminate the need for heavy rolling-mill equipment. The fourth example related to an aerodynamic study of the sinter plant at the Appleby-Frodingham Works, where fine iron ores are agglomerated prior to being charged into the blast furnaces. This piece of research has resulted in an increase in output of 66 per cent. above that expected when the plant was first installed. These four examples of plant-scale experimentation are dealt with more fully in this issue.

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## ELECTRICITY SUPPLY IN SCOTLAND

The debate on the second reading of the Electricity Reorganisation (Scotland) Bill, which took place in the House of Commons on Wednesday, February 3, and lasted nearly six and a half hours, singularly failed to disclose the real reasons for the introduction of this measure. The ostensible objects of the Bill are to transfer to the Secretary of State for Scotland the functions of the Minister of Fuel and Power in relation to electricity supply in that country, and to set up a new public authority, which will be responsible for generation, transmission and distribution outside the area of the North of Scotland Hydro-Electric Board. In introducing it, the Secretary of State said that by restoring to Scotland the management and control of its own affairs it would comply with the general wishes. This opinion, however, received little support from most of the Scottish members, one of whom could find no technical or economic reason for the change while another stigmatised the Bill as being dishonest, retrogressive and disadvantageous to the public.

Mr. Arthur Palmer pointed out, quite rightly, that the Bill was important to the United Kingdom as a whole and emphasised the danger of introducing legislation (presumably on political grounds), which did not correspond to technical requirements. This appears to us to touch the core of the matter. It has often been argued that the control of electricity supply in this country is over-centralised. In fact, Sir Arnold Gridley thought that a return might well be made to the conditions laid down in the Electricity (Supply) Act, 1926, so that power stations would again be under the control of those responsible for providing current to customers in their territory.

However that may be, and it is not an opinion that is universally held, it seems strange to begin devolution with an area which is among the least electrically developed in the country. For the present, installed capacity in South Scotland does not much exceed 1,000 MW, while the total installed capacity of the Authority is 17,200 MW with 9,400 MW under construction.

In fact, the policy laid down in the Weir Report that the country should be regarded electrically as a single unit is being disregarded and a national scheme, which, on the whole, has worked well, is being undermined for reasons which at least have no technical or, as far as can be ascertained, much other justification. It is more deplorable that this step is being taken at a time when the 275-kV grid is under construction and when the idea of linking this country with the Continent is receiving practical consideration. For electricity supply is a large-scale matter, a point which should be continually borne in mind when shaping policy. The Bill should, therefore, be limited to amalgamating the two existing Area Boards in South Scotland.

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## "PRODUCTION FOR PLENTY"

An exhibition of somewhat novel character, and an associated conference, are being planned by the Institution of Production Engineers, under the direction of its President, Mr. Walter Puckey, (who was Knighted in the New Year Honours). It will be held at Olympia, London, W.14, from July 7 to 14, inclusive. The theme of the exhibition is "Production for Plenty," and its unique feature will be that it will demonstrate the methods of production, in a wide variety of industries, rather than the end-products that result. The aim is to show, in Mr. Puckey's words, "the vast improvements that have taken place in some British industries; how much better other industries would be if similar improvements were introduced; and how much better off the nation would be if production was increased by the earlier application of our immense research activities." It is known that, in a number of industries, lessons learned by the British productivity teams during their visits to the United States have been applied with marked benefit; but British industry itself has never stood still, and developments making for greater efficiency are being continuously introduced. These, it is felt by the organisers, should be more widely known, and they hope that the Exhibition and Conference will result in a useful diffusion of such knowledge and experience.

Associated with the Institution of Production Engineers on the organising committee, which is under the chairmanship of Mr. H. Seaman, a director and general manager of the British Oxygen Company, are representatives of the British Productivity Council, the Trades Union Congress, the British Standards Institution and the Department of Scientific and Industrial Research. The Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., managing director of the National Research Development Corporation, has accepted the invitation of the Council of the Institution of Production Engineers to open the Conference by presenting the 1954 Sir Alfred Herbert paper. Further particulars may be obtained from the organising secretary, Mr. S. D. Cooke, Room 11, Avenue Chambers, 4, Vernon-place, London, W.C.1 (telephone: CHAncery 2223); or from the secretary of the Institution, Mr. W. F. S. Woodford, 36, Portman-square, London, W.1 (telephone: WELbeck 6813).

## SKIN MILLING OF LIGHT-ALLOY FORGINGS

### *Copying Machine with Magnetic Tape Control*

To perform the high-speed skin milling of complex light-alloy forgings and pressings, an American firm has developed a range of profile milling machines, incorporating variable-axis control. Known as the H.S.F. "Variax" series, these floor-type moving-column machines are made by the Giddings and Lewis Machine Tool Company, Fond du Lac, Wisconsin, and were designed, in particular, for use in the aircraft industry. In addition to template and pattern-copying devices, they can be equipped with "Playback" magnetic-tape control units which enable whole cycles of operations to be recorded and reproduced as required. The most comprehensive of the series is the HSF-4, which is capable of five pilot-controlled motions.

The five motions are: movement of the column along the ways; vertical movement of the saddle on the column; movement of the spindle to and from the work on a horizontal axis; angular rotation of spindle about a horizontal axis on segmental ways embodied in the saddle; and angular movement of the whole column assembly about a vertical axis, on segmental ways mounted on a secondary sliding base.

### AIRCRAFT COMPONENTS

This range of movement makes possible the rapid copy finishing of such aircraft components as bulkheads, spars, aerofoil profiles and larger integral structures, in which many features, including ribs, pockets and varying angles, must be accurately reproduced. The scope of these machines renders unnecessary the use of cumbersome rocking fixtures, synchronised to a machine cycle, and their speed of operation reduces inter-stage machining delays in forging processes.

The movements are normally controlled by templates, form patterns, or a combination of both. Separate tracers operate the various translations and rotations, and in the HSF-4 model three are provided.

### MAGNETIC-TAPE COPYING

Entirely automatic control is made possible by the introduction of the Playback control unit, which can be incorporated in the Variax machine and replaces the ordinary profiling methods. By recording complete cycles of operations on magnetic tape, this device enables long processes to be repeated identically without further setting-up or adjustment. The tape retains its qualities indefinitely, so that timed sequences can be stored in a small space; and errors, variation in settings and the handling of heavy templates can be eliminated.

The immense size and complexity of modern airframe structures, made possible by the introduction of heavy forging and extrusion presses, require increasingly lengthy and detailed milling processes. Thus, the more unwieldy templates become, the greater becomes the demand for such a condensation as that provided by magnetic-tape reproduction.

For less onerous requirements three simpler HSF machines have been designed. The HSF-1 is restricted to horizontal translations of the column and vertical movements of the saddle and is suitable for flash removal between forging processes. The HSF-2 has two perpendicular horizontal motions and a vertical one. The HSF-3 has, in addition to these, a rotation of the spindle in a vertical plane. The British agents for the machine are the Rockwell Machine Tool Company, Limited, Welsh Harp, London, N.W.2.

# CIVIL AVIATION AND THE GAS TURBINE

## LECTURE BY SIR MILES THOMAS

In the twelfth Brancker Memorial Lecture, given in London before the Institute of Transport on Monday, February 8, Sir Miles Thomas, D.F.C., M.I.Mech.E., Chairman of British Overseas Airways Corporation, discussed "The Impact of the Gas Turbine on Civil Aviation." Some extracts from his lecture, omitting the early sections dealing with the historical evolution of the commercial jet project which led to the Comet air-liner, are given below.

The first impact of the much higher speed of the Comet jet liner civil aircraft was the necessity for more accurate and faster navigation requiring better radio communications.

Another important aspect of the increased speed of the Comet, or other gas-turbine driven aircraft, is the vastly enhanced value of time spent on the ground. For this reason, under-wing high-pressure refuelling was developed so that the kerosene could be pumped into the tanks at the rate of 400 gallons a minute. An intensified need for co-ordinated traffic handling arose and the transit stop time of Comets has been reduced from an hour to forty minutes.

Since the gas turbine uses far less inflammable fuel, at night transit-stop passengers are allowed to stay on board the aircraft during refuelling, which reduces fatigue on long inter-continental journeys.

### ENGINE ECONOMICS

The initially higher cost of the gas turbine means that spare engines and parts must be utilised at a high rate. It means also an even greater need for pooling and sharing equipment between operators and for every effort to be made to salvage the expensive materials used in the "hot" parts of the engine during the overhaul processes.

The advent of the gas turbine means a greater consistency of performance throughout the flight, and because of the smaller amount of close fitting during overhaul, less maintenance man-hours per engine-hour of operation. The gas turbine will need to be designed expressly for air-line use if full advantage is to be gained, and we look to see the hot parts of the engine assembled so that they can be readily detached and replaced without disturbing the rest of the engine.

In the course of time maximum advantage will be taken of high-speed communications, radio and radar navigation aids and other devices to relieve the human factor of much of the work.

There has been a certain delay in the delivery of the Comet II because tests showed that it could well benefit from a modification to the shape of the leading edge. This improvement reduces stalling speeds and gives an improvement in the handling of the aircraft during take-off and landing. The stalling speed in the landing configuration is reduced by about 6 knots. It also improves the payload by some 2,000 lb.

After the alterations had been made to the leading edge, the take-off characteristics were such that it was possible to get the aircraft taking off at such a steep angle that the flow of air to the engines was slightly restricted. Therefore similar alterations to the configuration of the air intakes to the Avon engines had to be made. That is an example how an improvement of a technical nature slows down the aircraft delivery and has an almost cumulative delay. The people who suffer mainly are the initial operators. The two Corporations, B.O.A.C. and B.E.A., deserve financial recompense for the pioneering work that they have done and will be doing. Those who have ordered subsequent Comet II's will not have their delivery dates affected.

### TURBINE DEVELOPMENT POSSIBILITIES

The straight jet is very fast and reasonably economical. The turbo-prop is reasonably fast and very economical, but, by reason of its airscrew mechanism, is more complicated, and so the overhaul costs may to some degree offset its fuel economies. It provides reverse thrust for braking, without further mechanical devices.

The jet aircraft is inherently less flexible and it is economically less easy to take advantage of its high speed. It is likely that the jet will always be more specialised in its use and less easy to operate comparatively short distances. The turbo-prop is more versatile.

One of the attractive features of all types of gas-turbine aircraft is that they are only at the beginning of their development, whereas piston-engine development has reached a high degree of near perfection. In the effort to get the last ounce of power out of piston engines, exhaust-gas turbines are now employed to drive super-chargers or to feed back power to the main crankshaft. Fundamentally, it seems that any attempt to extract extra power from the already tortured exhaust-gas system must place heavier duty on the exhaust valve guide.

In contrast, already in the test shops of the jet engine manufacturers, substantial and fundamental advances are being made. Compression ratios of up to 15 to 1 are being incorporated in new designs.

### DIESEL FUEL

Airline fuel specifications cannot be decided on purely technical grounds. Costs have to be considered since fuel costs represent more than a quarter of the operating cost of jet aircraft. The possibility of using one of the Diesel oils, which are readily obtainable and have greater heat content, is therefore being examined.

Other advantages would be a greater range of flight from the same tank capacity, and a lower risk of fire in the case of accident, owing to the higher flash point and lower volatility of the heavier fuel; on the other hand, pumping difficulties at low temperature, and associated fuel-system complications, will have to be weighed against these gains.

In the case of the Comet I tankage capacity approaches 50,000 lb. weight of kerosene, and forthcoming trans-Atlantic jet-propelled air-liners will probably require double this quantity; yet the time available for refuelling will be the same. It is necessary to plan now for faster refuelling.

The increase of electrical power for starting sets is already evident. With some previous piston-engined types 23 h.p. sufficed for running the ground generator; now 150 h.p. is required to take care of the increased starting load to spin the gas turbine to minimum speed for lighting. Instead of mobile tankers, coaches, starter-trucks, etc., on the apron area, the airliner should be docked so that static service pipelines, weather-proof gangways, etc., can be coupled up without fuss or delay.

Airports require to be developed to handle jet-aircraft traffic more efficiently, e.g., in respect of the speed of response to radio communication, instrument landing aids, ground-controlled approach aids, stacking patterns, and taxying control.

### THE JET NOISE PROBLEM

The noise characteristics of a turbo-jet aircraft are highly directional; the layout of the airport could therefore be planned so that these noise effects are minimised.

The gas-turbine engine automatically means less ground running prior to departure and in the vicinity of the hangars. Attempts are being made to reduce this even further by providing external sources of energy for functional testing of all kinds, so as to avoid using the main engines for the purpose.

### FLYING BOATS

As aircraft increase in size, it is probable that it will be essential to use the sea or large lakes as airports. But so far as the present range of weight is concerned, the range of projected turbine aircraft fit into the current international airport pattern. Indeed, they must do, if anyone is to be persuaded to buy them. The flying-boat pioneer must then bear the whole cost of the ground-based equipment.

Whether the durability of the jet engine operating in a flying boat will measure up to commercial standards—the design of the hull; the shape taken by the bow-wave and spray on take-off and landing in relation to air-intakes; the effect of wet salt air when at moorings – all these problems can be decided only in usage.

### ENGINE INTERCHANGEABILITY

With the pace of engine development possibly outstripping aerodynamic development, it may be wise to make provision for fitting engines of varying types into future airframes. In the development of the Comet, the stipulation that the Rolls-Royce Avon engine should go into the same available space as did the Ghost engine saved the manufacture of two entirely different sets of wings.

In the future, the virtues of the straight jet (which emits a comparatively slender but highly energised efflux from its turbine) may be combined with the good features of the turbo-prop, possibly in the form of a ducted fan. The diameters of engines might be considerably altered in this process. In designing new aircraft, if their engines were outside the wing in pods, a greater degree of flexibility of engine size and characteristics could be accommodated without disruption to a whole fleet. A gas-turbine unit thus slung outside the wing could more readily carry the necessary mechanism to achieve reverse-thrust when required.

### TARGETS FOR TO-MORROW

In the broadest terms, B.O.A.C. are looking for aircraft capable of carrying something under 100 passengers in first-class luxury configuration but considerably more than 100 people if fitted with high-density tourist type seating.

One of them should fly at 550 miles an hour, both must fit into the existing airport pattern, one should have a stage length of 4,000 miles (allowing for the usual reserves) and very low costs. Both should have ten-year life and operating costs that will enable them to make a profit with a 45 per cent. load factor at present first-class and tourist rates, fuel costs and the like. Such aircraft are capable of production for the post-1960 era.

# EXPERIENCE OR TRAINING?

## SUPPLY OF MANAGERS FOR IRON AND STEEL INDUSTRY

The sixth conference sponsored by the Training Committee of the British Iron and Steel Federation, held at Ashorne Hill on October 21 to 23, 1953, was concerned with "Education and Training for Management in the Iron and Steel Industry." Although iron and steel manufacture presents some managerial problems different from those met with in general engineering, the opinions expressed and the experiences recorded in the report* of the conference should make it of interest in a wide circle.

Sir Andrew McCance, with perhaps pardonable exaggeration, said that "the Universities had continued to concentrate on the classics in the belief that an intimate knowledge of what happened a couple of thousand years ago within the Greek or Roman Empires was an adequate training for dealing with all the possibilities or the perversities of human nature and behaviour." This is hardly a fair picture of the universities in the year 1954, but the effect of the tradition still persists; it is fundamentally the reason why most schoolmasters encourage their pupils to concentrate on "pure" subjects as their life work, the prospects offered by, and the needs of, industry being largely ignored.

### FEWER CANDIDATES STRAIGHT FROM SCHOOL

The majority of the speakers at the conference by no means suggested that the universities were the only source of future managers, but, as Mr. N. R. R. Brooke pointed out, one effect of the 1944 Education Act was that the number of more intelligent boys available directly from school to industry was becoming increasingly smaller; the proportion passing from school to a university had greatly increased, so that industry had to employ more graduates. The qualities and defects of university-trained men were discussed: some, when they found themselves in the shops, were so ill at ease that they wanted immediately to return to the laboratory; some were astonished at the ignorance of the works' people and proceeded to instruct them; some were sensible enough to realise their own ignorance of practical affairs, to say little and do their best to learn.

In addition to graduates, secondary-school boys were still a source of supply. If they entered industry at the age of 15 they would obtain practical shop experience which would form a valuable background for future managerial status. Opinions differed about whether university graduates should be subjected to a period of manual labour in the shops; it was favoured by some, others thought that the personal experience it afforded was amply provided by two years of National Service.

Little has yet been said about training, which was the postulated subject of the conference. There was considerable discussion about the various management-training courses provided by some of the universities and technical colleges, and the week-end, or longer, courses at residential colleges. In addition to the full sessions of the conference, a number of small study groups held meetings. Two of these were concerned with full-time courses in management subjects and another two with part-time studies.

* *Education and Training for Management in the Iron and Steel Industry.* British Iron and Steel Federation, Steel House, Tothill-street, Westminster, London, S.W.1.

### TEACHERS FROM INDUSTRY

The study groups dealing with part-time courses considered that they were valuable but could only be fully effective if industry maintained constant touch with the organisations providing them. Experienced men should be lent by industry to help in the instruction and to keep the teaching staff in touch with works' conditions. It is not only for future higher executives that training courses are provided and the opinion was expressed that they should be available for all grades of worker. A considerable number of courses for foremen are now held and this has a bearing on the question of the future supply of managers.

As widely practiced in some other branches of engineering, some large iron and steel firms provide their own training courses. Mr. W. F. Cartwright, of the Steel Company of Wales gave some particulars of the practice of his firm. Men with Higher National Certificates, or with degrees, were placed for a year or 18 months, in the Operational Research Department. Here, they were given a wide variety of jobs planned to give them an insight into the works as a whole; considerable experience in dealing with other people was afforded.

Mr. Cartwright suggested that it was after a year or so in the Operational Research Department that the difficult stage in managerial training was reached. The practice was to post the trainees as junior engineers or junior assistants in the works, the remainder of their training being provided by individual coaching by the manager under whom they worked. Unfortunately "there was an enormous variation in the ability of managers to give this personal coaching." Some did not believe that they had any duty in the matter; some were actively bad; some, but unfortunately few, were really good trainers. "If it became obvious that a manager was not giving his assistants this personal attention and training, it was the responsibility of higher management to convince him that he had a duty in this respect."

### ARTS GRADUATES

Something was said at the conference about the much-discussed subject of the employment of arts graduates in industry. Sir Andrew McCance thought that in spite of the great increase in the number of university graduates, the number of first-grade men had hardly increased at all. No speaker exactly put it this way, but it is clear that industry cannot expect to be staffed entirely by first-grade men. There are not enough in any walk of life. As there are not only not enough first-grade future managers, there is also a shortage of those of competent but average type being provided by the usual sources of supply. Mr. Brooke suggested that industry could not afford to neglect arts graduates as a source of recruitment. Many had intelligence and trained minds and were able to learn relatively quickly, sufficient about technical matters to work satisfactorily in many production departments. There were many jobs for which advanced technical knowledge was not required and in which a science graduate's knowledge would be largely wasted. Professor F. A. Vick of the University College of North Staffordshire pointed out that his four-year arts graduates received some instruction in science; they should be of value in industry.

Two matters were mentioned in which arts graduates might possibly show superiority over average technically-trained men. It was said that people were frequently "extremely inarticulate" and that when foreign visitors were received at works they nearly always had some knowledge of English, but when representatives were sent to foreign countries they knew little or nothing of the language spoken.

# FIFTY YEARS OF HEAVY ENGINEERING PLANT

In the course of his presidential address, delivered to the Sheffield Society of Engineers and Metallurgists on January 18, Mr. R. E. S. Fisher, M.C., M.I.C.E., A.M.I.E.E., said that he had entered the River Don Works of Messrs. Vickers, Son and Maxim, Limited, Sheffield (now the English Steel Corporation, Limited), as an engineering pupil in 1908, and he felt that it might be of interest to recall some of the plant in use there at about the beginning of the present century. The open-hearth melting installation then consisted of eight furnaces each of 15 tons capacity and three furnaces each of 25 tons capacity. On the tapping side the largest ladle had a capacity of 25 tons. Gas was supplied to the 11 furnaces by 36 rectangular producers.

An early steam-driven tyre-mill plant and accompanying equipment for cogging tyre ingots had been in use until about 1932; the installation produced about 30 tons of tyres in one shift, the diameters ranging from 2 ft. to 8 ft. 6 in. Hydraulic jib cranes were employed for lifting the blooms and tyres. The works' first electric central power station had been installed not only for lighting but also for driving machinery. The generating plant consisted of four Siemens shunt dynamos coupled direct to four Belliss compound engines. Running at 380 r.p.m., the engines developed 250 indicated horse-power, the output of each dynamo being 735 amperes at 215 volts. The total capacity was, therefore, 1,000 indicated horse-power and 2,940 amperes. There was an exceptionally strong stray magnetic field in the region of the dynamos. All the bolts and nuts were so highly magnetised that, when a spanner was used, difficulty was experienced in removing it from a nut. On one occasion, a breakdown had been caused by an attendant passing the end of the dynamos carrying a billy can having a loose-fitting lid which had been attracted into the brush gear by the magnetic field.

The first forging press, a 2,500-ton hydraulic machine, had been put down in 1882, and had continued in operation until scrapped in about 1933. Among other forging equipment, a 27-in. press of 1,430 tons had been installed in 1900 for forging locomotive crank axles. It was still in use for the closing of boiler drums and for producing small hollow forgings, crankshafts and general forgings, but electric hydraulic pumps had been installed in 1938. The armour-plate rolling mill, a steam-engine driven two-roll mill, the rolls being 3 ft. in diameter by 12 ft. long, had been installed about 1888. The mill and its engines were still working, the only modification being that the battery of Lancashire boilers previously in use was being replaced by two Ruths steam accumulators.

## *Letter to the Editor*

### CALCULATION OF THE THICKNESS OF HIGH-TEMPERATURE STEAM PIPES

SIR, May I point out the fallacies in Dr. J. S. Blair's argument, in his article on page 549 of your issue of October 30, 1953, that the initial elastic stress distribution will be replaced by one in which the hoop stress is uniform over the section.

He wrote . . . " there is no need to be seriously concerned with theories which purport to determine the combined stress under creep conditions, since in fact the amount of creep depends upon the stress raised to such a high power that virtually all the creep will take place in the direction of the major (principal) stress " . . Firstly, since plastic flow is at almost constant volume, flow in one direction must be accompanied by flow in the other principal directions. Secondly, it does not follow that the rate is independent of the stresses acting in the other two principal axes, because the flow rate is very stress sensitive. Experiments by R. W. Bailey (*Proc. Inst. Mech. Engrs.*, Vol. 131 (1935)) show that the creep rate in one direction is a complex function of the maximum shear stresses, i.e., the differences of the principal stresses. This is to be expected as plastic deformation is usually independent of hydrostatic stresses.

On the other hand, Dr. F. van Iterson is a trifle dogmatic in asserting in his letters on page 131 *ante* and on page 723 of your issue of December 4, 1953, that his equation is the exact solution. The equation has been proved experimentally only in short time tests with relatively high rates of loading. But we know that the mechanism of deformation during creep is different. It has also been derived by plastic theory, supposing an ideal material with a sharp yield obeying the maximum stress difference criterion and exhibiting no creep. The same equations can be derived for creep conditions as follows.

Suppose the creep rate in a principal stress direction is proportional to the reduced stress:

$$\dot{\epsilon}_1 = \lambda\left(\sigma_1 - \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}\right).$$

Let the value of $\lambda$ be governed by a maximum shear stress hypothesis

$$\lambda = A\,(\sigma_1 - \sigma_3)^n$$

where A and $n$ are constants of the material. In a pipe the cross sections perpendicular to the axis must remain plane for reasons of symmetry. Then in the axial direction:

$$\dot{\epsilon}_2 = c = \lambda\left(\sigma_2 - \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}\right).$$

Hence

$$\dot{\epsilon}_t = \frac{A}{2}\left(\sigma_t - \sigma_r\right)^{n+1} - \frac{c}{2}.$$

Now $\dot{\epsilon}_t$ is greater for the fibres at the inside than the outside of the tube, because the volume of metal remains constant. But owing to the large value of $n$, i.e., creep rate is very sensitive to stress, $\sigma_t - \sigma_r$ may be treated as independent of $r$. This is the same as in normal plastic theory and the same equations for stresses are derived as quoted by Dr. van Iterson.

The hoop stresses are given by:—

in elastic range, $$\frac{\sigma_t}{P} = \frac{1}{\left(\frac{r_2}{r_1}\right)^2 - 1}\left\{1 + \left(\frac{r_2}{r}\right)^2\right\}$$

in creep range, $$\frac{\sigma'_t}{P} = \frac{1 - \log_e\left(\frac{r_2}{r}\right)}{\log_e\left(\frac{r_2}{r_1}\right)}.$$

The values of $\sigma_t$ and $\sigma'_t$ for a tube with $r_2 = \frac{3}{2}\,r_1$ are:

| $r$ | $\cdot 66r_2$ | $\cdot 77r_2$ | $\cdot 88r_2$ | $r_2$ |
|---|---|---|---|---|
| $\frac{\sigma_t}{P}$ | 2·6 | 2·2 | 1·8 | 1·6 |
| $\frac{\sigma'_t}{P}$ | 1·5 | 1·8 | 2·2 | 2·5 |

If the initial loading is regarded as elastic and the final conditions are governed by the above creep-plastic theory, there is an initial tendency for the hoop stress to become uniform but non-uniform plastic distribution will be established rapidly. The ratio of the maximum to minimum hoop stress can be shown to be the same for elastic and plastic states, independent of $\frac{r_2}{r_1}$.

If the design is to be based on creep rupture, we shall now require further information on how this effect is governed by three dimensional stresses.

Yours faithfully,
O. H. WYATT.

University of Cambridge,
Engineering Laboratory,
Trumpington Street, Cambridge,
February 5, 1954.

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## *Obituary*

### MR. A. CAMPBELL

#### A Pioneer of Electrical Measurements

We regret to record the death of Mr. Albert Campbell, which occurred at Cambridge on Saturday, February 6, in his ninety-second year. He was well-known to the older generation of electrical engineers for his work on the measurement of magnetism, inductance and other phenomena and as the inventor of a number of instruments for this purpose.

Albert Campbell was born at Londonderry on April 16, 1862, and was educated at the Academical Institution in that city. He afterwards studied at the Universities of Edinburgh and Cambridge, graduating in both the mathematical and natural science triposes. On leaving Cambridge he acted as a science master at Clifton College for a short time and then took courses in mechanical and electrical engineering at the Central Technical College, London. After serving on the staff of the Faraday House Standardising, Testing and Training Institution, where he took part both in teaching and in experimental work on electrical measurements, he was appointed in 1901 to the position of principal assistant at the National Physical Laboratory, and was engaged there until his retirement in 1918, at the same time as the first director – Sir Richard Glazebrook.

He was the author of numerous papers on various aspects of electrical measurement which were published in the *Proceedings* of the Royal Society, the Institution of Electrical Engineers and the Physical Society. He devoted much attention to the measurement of inductance and was the inventor of a primary standard for this quantity as well as of subsidiary standards for other alternating-current measurements.

Campbell was elected an Associate Member of the Institution of Electrical Engineers in 1901 and had served on the Council of that body. He had also been a vice-president of the Physical Society and was the recipient of the Duddell Medal in 1925.

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*We also regret to record the deaths of the following:*

MR. J. C. ARKLESS, F.C.I.S., at Newcastle-upon-Tyne, on February 1. Mr. Arkless, who was 63, was a director and secretary of A. Reyrolle & Co. Ltd., Hebburn-on-Tyne. He had entered the firm in 1904.

MR. ALEXANDER BOWMAN, at Gourock on January 17. He had been manager of the ship-repairing branch of Scotts' Shipbuilding and Engineering Co. Ltd., Greenock, for 32 years and retired at the end of last year.

MR. FREDERICK HICKEY, R.C.N.C., M.Inst. N.A., at Hastings on January 27, at the age of 67. Until his retirement in 1946, Mr. Hickey was Assistant Director of Naval Construction, Admiralty.

MR. A. CAMPBELL HOLMS, recently, in his 93rd year. A naval architect, he joined the staff of Lloyd's Register of Shipping in 1890 and served in Belfast, Glasgow, Sunderland, Newcastle, London and Liverpool. He retired as principal surveyor in Liverpool in 1924.

MR. N. H. MILLER, A.M.I.E.E., on January 29, at the age of 61. He was assistant liaison officer of British Insulated Callender's Cables Ltd., having joined the firm in 1920.

MR. M. W. RONAYNE, suddenly on Friday, January 22. He joined the staff of G. A. Harvey & Co. (London) Ltd., Greenwich Metal Works, London, S.E.7, in 1920 and was manager of their zinc and ironworks departments at the time of his death.

MR. C. A. GOODALL, on February 3, at the age of 78. He was managing director and secretary of Goodall, Clayton & Co., Ltd., colliery engineers, Pepper Road, Hunslet, Leeds, 10.

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## PERSONAL

The title of Professor of Civil Engineering has been conferred upon MR. J. W. H. KING, M.Sc. (Manch.), in respect of the post held by him at University of London, Queen Mary College, Mile End-road, E.1.

MR. J. C. DENHOLM, C.B.E., M.Inst.T., has been nominated President of the Chamber of Shipping of the United Kingdom, 3-6, Bury-court, St. Mary Axe, London, E.C.3, for the current year. MR. A. I. ANDERSON, has been nominated vice-president and the Council have co-opted MR. C. W. ASTON, SIR RONALD GARRETT, SIR J. GIBSON GRAHAM, the HON. J. S. MACLAY and MR. R. S. MACTIER as members for the ensuing year. The annual meeting of the Chamber will be held on Thursday, February 25.

SIR LYNDEN MACASSEY, K.B.E., Q.C., LL.D., D.Sc., has not sought re-election as independent chairman of the British Internal Combustion Engine Manufacturers' Association, 6, Grafton-street, London, W.1. Following this decision, the Council announce that a chairman of Council, assisted by a director will be elected in place of an independent chairman. Mr. W. K. G. ALLEN, M.I.Mar.E., A.M.Inst.N.A., is the new chairman and Mr. C. C. M. LOGAN, T.D., M.A., the new director.

MR. E. J. LARKIN, A.M.I.Mech.E., M.I.Loco.E., has been appointed assistant mechanical and electrical engineer, Derby, London Midland Region, British Railways. MR. E. S. HUNT is to be assistant chief regional manager; Mr. S. T. CLAYTON, motive power superintendent and MR. B. ADKINSON assistant motive power superintendent, all three at Euston.

MR. B. R. CARTER, son of the chairman and managing director of B. and F. Carter & Co., Ltd., Albion Works, Bolton, has been elected to the board of the company.

MR. LEON BAILLY, M.Inst.F., has relinquished his directorship of the International Furnace Equipment Co. Ltd., Aldridge, Staffordshire. He will in future operate mainly in France and Belgium in conjunction with Le Gaz Intégral, of Paris, with whom the International Furnace Equipment Co. are closely associated.

MR. A. A. CROSS has succeeded MR. T. C. HALE as plant manager, Harts-lane, Barking, factory of the Cape Asbestos Co. Ltd. Mr. Hale is now at the firm's head office, 114, Park-street, London, W.1, as director (technical). Mr. Cross's place as plant manager Acre Mill, Hebden Bridge, Yorkshire, has been taken by MR. A. E. HEPPER. MR. L. H. SMART is to be manager of a new plant at Stirling and his place at Kentmere, Westmorland, has been taken by MR. H. ELLIOTT.

## R.A.E. TECHNICAL COLLEGE

" Learn to like to work " was the advice given by Sir William Farren, C.B., M.B.E., F.R.S., President of the Royal Aeronautical Society, in his address after distributing awards at the Annual Presentation of Prizes, at the Royal Aircraft Establishment Technical College at Farnborough on Monday, February 1.

Speaking from his own experience as student, teacher, research consultant, administrator and aircraft constructor, he said that it did not matter much what an engineering student studied, provided that the foundations of his knowledge were kept as wide as possible. A difficult problem had been created by the continual revelation of new scientific wonders, and since it was out of the question for the student to learn more subjects, the teacher must be prepared to scrap much of what he had relied on in the past. In speaking of wide interests he did not mean " snippets " of everything, but the cultivation of accuracy in experimental observation and clarity in analytical reasoning. Practice and theory were complementary. If a man were a good observer he should be encouraged to develop his theoretical powers, and if he were good at bookwork his nose should be rubbed in practice. The Wright brothers offered the supreme example of successful combination of theory and practice. Since they had no elements of either on which to build, they had to make both for themselves. Referring to the excellent results obtained by the students during the past session, Sir William affirmed that the reputation of the College already stood very high.

The report on the year's work was presented by Mr. R. D. Peggs, Principal of the College, who listed 12 final degrees, 65 Higher National Certificates, and 90 passes, including 44 at first-class level, in the final examinations of the City and Guilds of London Institute, together with several individual results of outstanding merit.

Looking back on the 10th anniversary of his appointment as Principal, Mr. Peggs paid tribute to the inspiration and vision of the founders of the College in its present form – Sir William himself, Mr. Perring (lately Director, R.A.E.), Sir Henry Guy, Sir Archibald Rowlands and Sir Stafford Cripps.

Mr. A. A. Hall, F.R.S., Director of the Royal Aircraft Establishment, who presided, announced that the Board of Governors, under the chairmanship of Sir Frederick Handley Page, was being replaced by the R.A.E. Technical College Advisory Board, under the chairmanship of Sir William Farren.

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## PROMOTION OF INDUSTRIAL EFFICIENCY BY LEVIES

The Industrial Organisation and Development Act of 1947 enabled the Board of Trade and certain other authorities to impose charges on industry for scientific research, the promotion of export trade and the improvement of design. The Industrial Organisation and Development Bill, 1954, the text of which was published on Saturday, January 23, extends the scope of this measure by adding purposes " tending to promote productive efficiency." The new Bill also makes it possible for a levy to be imposed on an industry which has a development council if an order dissolving that council has been made. No additional net charges are likely to arise from this provision, since power is taken to recover the cost of administering an order imposing a levy.

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## SCOTTISH MOTOR SHOW

A motor show is to be held annually in Scotland instead of one every second year as in the past. The Scottish Motor Trade Association, the organisers, state that the arrangement will begin next year, when an exhibition will be held in the Kelvin Hall, Glasgow, from November 11 to 19.

# AIDS TO PRODUCTIVITY

## A REVIEW OF THE VALVE INDUSTRY

Specialisation, standardisation and simplification were three approaches recommended in the report. *Steel, Iron and Non-Ferrous Valves* (3*s.* 6*d.*), presented by the Valves Productivity Team which visited the United States in 1950. An account of the valve industry's response to these proposals is given in a booklet entitled *A Review of Productivity in the Valves Industry* (2*s.*), which contains information of interest also to other engineering firms. It is the twelfth of a series of productivity reviews published by the British Productivity Council and copies may be obtained on application to the Council, at 21, Tothill-street, London, S.W.1.

In the United Kingdom, the output of the valve industry has, since 1946, increased in value by 434 per cent., so that in 1953 the value of its production was nearly £27 millions – more than five times the 1946 figure. Exports have expanded at an even greater rate than production and at present 37 per cent. of the valves made are for overseas markets. The value of valve exports for 1953 was nearly £10 millions, 561 per cent. of the 1946 total; and, as observed in a review published by the Information Division of the Treasury, this represents an increase exceeding those of the other 16 major engineering industries quoted in that publication.

The increase in output of the valve industry has been much greater than the expansion of the labour force, which now numbers just over 15,000 employees. Improvements in methods of manufacture have brought about an appreciable rise in labour productivity and at a rate somewhat higher than in industry as a whole, wherein it has been a little over two per cent. per year.

### STANDARDISATION AND PRODUCTIVITY

The means by which productivity has been raised are listed in the review in terms of the suggestions originally made by the productivity team, but many of the improved methods were adopted independantly on the initiative of the firms concerned.

The review states that whereas in 1935 over 50 per cent. of the valve output came from companies concerned mainly with other products, the 1948 Census of Production indicates that 85 per cent. comes now from firms specialising in valves. Specialisation is also pursued within the industry. Many companies tend to restrict manufacture to a given range which may be identified by the metal principally used in construction, the type of valve, or its application, as in the case of steam or petroleum valves. A few companies continue to make many types, or to produce special models to meet customers' individual requirements.

One firm which formerly made valves of varying shapes and sizes now confines itself to a range from $\frac{1}{4}$ in. to 3 in., each size fabricated to a standard basic design. The standardisation of certain other types of valve has been achieved through the agency of the British Standards Institution, and about eight models made to the Institution's specifications have been adopted since the war.

The effect of simplified design on ease of production has been examined by some companies and one has appointed a committee for this purpose. The simplification of production methods by the introduction of special-purpose machine tools is studied by another of the same company's teams. Valves have been redesigned so that components may be common to several models, and effective and economic use made of machine tools. Exchange of information within the industry has both simplified the range of products and circulated improvements in manufacturing techniques.

### COSTING AND PRODUCTION CONTROL

Certain firms have devised material and production control systems so that materials, tools and information arrive at the right place at the right time. Decentralisation of authority has sometimes led to more efficient organisation; and in other cases greater attention has been given to progressing and detailed costing. Regular analysis of costs has often provided the main guide to improvement of methods.

Accurate costing led to the realisation that the waste of raw material in scrap might economically be prevented by the installation of new machines. One concern discovered that some 20 to 25 per cent. of the metal used in making small spindles ended in scrap because the machines employed were unsuitable for the purpose. New machines almost eliminated the losses.

Many materials handling appliances have been introduced, foundries have been mechanised and, by planned production flow, inter-operational handling has been reduced to a minimum. Conveyors, compressed-air hoists and electric trucks are used extensively, and pallets and stillages, which at one factory have been fitted with castors, have facilitated the storage and movement of components.

### DOORS OPENED PNEUMATICALLY

One large company has installed a compressed-air control system for all communicating doors through which trucks are driven; the doors can be operated by means of a press button which the driver can reach without dismounting.

Many factories have been equipped with new machinery; one effect has been to ensure closer tolerances than were formerly common. In general, the industry has used its prosperity to good purpose by re-investment in up-to-date plant.

Piece-work payment has been greatly increased during the post-war years, as have various other types of financial incentive. One company, by its group bonus scheme, has achieved an increase in foundry output of 30 to 40 per cent. Another result of the spread of mechanisation has been a pronounced increase in earnings as prosperity in the industry has mounted. Some firms have suggestion schemes, and one has been able to accept one suggestion in four. The necessity of extending work study in the industry is being widely recognised. In at least one factory output has doubled with only a ten per cent. increase in labour and a five per cent. increase in machines.

### INVESTMENT REWARDED

Nevertheless, the improvements in productivity that have been achieved in the valve industry – and others – are mainly related to the amount of capital equipment installed. " Those firms which have invested a large amount of capital in equipment tend to be those showing the most encouraging results." It is significant, furthermore, that this industry has not only taken full advantage of modern methods of increasing productivity but also, perhaps in consequence, has become one of the most prosperous of Britain's industries.

# MILITARY OPERATIONAL RESEARCH

## *Use of Water-based Aircraft*

That insufficient effort is now being devoted to operational research in Great Britain's military forces was the principal theme of a lecture given by Group Captain G. W. Williamson, O.B.E., M.C., F.R.Ae.S., before the Royal United Service Institution in London on Wednesday, February 3. Much of the lecture, which was entitled "Operational Applications for Water-Based Aircraft," dealt with recent American developments in water-borne aircraft, such as the use of hulls with higher length-to-beam ratios, retractable steps, and spray dams, and the replacement of conventional hulls by "hydro-skis" and hydrofoils.

As one speaker pointed out in the discussion which followed, parallel researches have been carried out in the United Kingdom, and in some respects it is believed that they have progressed further than those of the United States – but whereas no Government contracts have been placed in Great Britain for flying boats embodying the results of such work, in the United States advanced marine-based aircraft are already under construction, including a supersonic delta-wing machine mounted on skis.

It was not, Group Captain Williamson said, for him to say whether the water-based aircraft should have a place in military aviation; with the advent of nuclear propulsion and atomic weapons, sea warfare in the future would be very different from what it had been in the past. He considered that it was essential for an operational research team of highly-qualified scientists to study the best way of attacking the submarine menace, and whether the flying-boat should play a part. During the second world war, the recommendations of operational research teams in Coastal Command and in the United States had saved many merchant ships and had trebled the sinkings of submarines. Since the end of the war, operational research had not been sufficiently maintained by the Services.

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## RADIO-ISOTOPE CONFERENCE AT OXFORD

Arrangements are being made to hold a second radio-isotope conference at Oxford from Monday, July 19, to Friday, July 23, and the final programme is expected to be available next month. Medical and biological applications of radio-isotopes will be dealt with during the first three days. Chemical and metallurgical aspects will receive attention on July 22, and physical, engineering and industrial applications will be considered on the closing day. Applications to attend should be made to the conference secretary, Atomic Energy Research Establishment, Harwell, Berkshire.

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## COURSE ON CORROSION AND PACKAGING

A special course of five lectures dealing with "Corrosion and Packaging" is to be held in the Department of Applied Chemistry of the Northampton Polytechnic, St. John-street, London, E.C.1, on Wednesday evenings at 7 o'clock commencing on March 10. The lecturers will be Dr. W. H. J. Vernon, O.B.E., who will speak on "General Principles of Corrosion"; Mr. J. J. Ferriggi, whose subject is "General Principles of Packaging of Corrodible Articles"; Dr. D. Clayton, whose lecture deals with the "Prevention of Corrosion"; Mr. D. J. Evans, who will deal with "Barriers and Desiccated Packs," and Mr. F. A. Paine, who will speak on the "Selection of the Packaging Method." The fee for the course if £1 1*s.*

## FILMS OF FORTY ENGINEERING FIRMS

### Roads, Agriculture and Materials Handling

The Owen Organisation, Kent House, Market Place, Oxford Circus, London, W.1, possesses a film unit and has recently published a catalogue of 16-mm. films illustrating the manufacture of parts for the motor industry, many types of agricultural equipment, road-making machinery, mechanical-handling appliances and the full story of the B.R.M. racing car.

These films deal with products made by the member companies of the Owen Group, which, with the parent organisation, Rubery, Owen and Company, Limited, Darlaston, South Staffordshire, number nearly 40 engineering firms. The Group has, at its offices in London, an attractive, modern theatre which is used for showing to customers and suppliers its own and other companies' films. Films are also available for loan to both professional and amateur organisations outside the Owen Group.

The Group's catalogue lists silent and sound films ranging in length from 5 to 35 minutes. A typical film called "Down to Earth" and lasting 20 minutes shows disc ploughs and other machinery made by Salopian Engineers, Limited, Press, Shropshire. Colour films have been produced and one, presenting the Owen Organisation as a whole, will be available during the Spring.

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## INSTITUTION OF NAVAL ARCHITECTS

### Samuel Baxter Prize for Safety at Sea

Under the will of the late Mr. Arthur William Baxter, a sum of £2,000 has been left to the Institution of Naval Architects, the income from which is to be applied to the giving of an annual Samuel Baxter Prize (or Prizes) for the best contribution received during the year on the subject of safety and/or efficiency in sea-going vessels. The Council have decided that the authors of all papers accepted during a calendar year shall be considered eligible for the award, and that when presenting such papers, it will not be necessary for the author to state that he is competing for the Prize. Other papers, essays, or description or drawing of any new design, invention, process, equipment or apparatus specifically submitted for the Prize will also be considered. About £60 a year is available and the Institution will review and determine the question of awards as soon as practicable after December 31 each year. Further particulars may be obtained from the secretary of the Institution, 10, Upper Belgrave-street, London, S.W.1.

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## MINISTRY OF SUPPLY TRAINING SCHEME FOR CHEMICAL ENGINEERS

A four-week intensive "Practice School" in chemical engineering will be held at the Royal Ordnance Factory, Bridgwater, Somerset, during the summer, the provisional dates being from August 16 to September 13. The Ministry of Supply are setting up the school as a contribution to the training of chemical engineers in Britain. No fee will be charged for the course and students will receive an allowance of £4 2*s.* 6*d.* a week while the school lasts, with free travel to and from their homes. The school will be open to honours students in their final university year. During their stay at Bridgwater they will study problems relating to chemical plant under Mr. E. S. Sellers, M.A., M.Sc., A.M.I.Chem.E., of the University of Cambridge; they will meet technical staff from the factory for group discussions. Students will be accommodated in a hostel nearby at a cost of about £2 15*s.* per week. Application forms are obtainable from the Director of Ordnance Factories (Administration and Finance), Room 88, Ministry of Supply, Leysdown-road, Mottingham, London, S.E.9.

# LAUNCHES AND TRIAL TRIPS

M.S. "MIMOSA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the Tankers Shipping and Trading Corporation, Panama. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,600 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder two-stroke single-acting Diesel engine, developing 6,800 s.h.p. at 112 r.p.m. Service speed, 15 knots. Launch, December 17.

M.S. "BJÖRGSUND."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for A/S Hakedal (Managers: Hjalmar Björge), Oslo, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, 18,150 tons on a draught of 30 ft. 4½ in.; oil-tank capacity, about 860,800 cub. ft. Eriksbergs-B. and W. nine-cylinder two-stroke single-acting Diesel engine, developing 9,000 i.h.p. Speed, 15¼ knots, fully loaded. Delivered, December 19.

M.S. "HUNTFIELD."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for the Hunting Steamship Co., Ltd., Newcastle-upon-Tyne. Main dimensions: 495 ft. between perpendiculars by 69 ft. 6 in. by 40 ft. 4 in.; deadweight capacity, about 16,650 tons on a draught of 30 ft. 2 in. Six-cylinder opposed-piston oil engine, constructed by William Doxford and Sons, Ltd., Sunderland. Speed 15 knots. Launch, December 21.

M.S. "CAPETAN KOSTIS."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Tramp Chartering Corporation, Panama. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck. Swan Hunter-Doxford four-cylinder oil engine, arranged to burn boiler fuel and developing 4,800 b.h.p. at 115 r.p.m. Launch, December 21.

S.S. "ARAFURA."—Single-screw cargo vessel, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the Eastern and Australian Steamship Co., Ltd., London, E.C.3. Main dimensions: 482 ft. by 63 ft. by 39 ft. to upper deck; deadweight capacity, 10,800 tons; gross tonnage, 9,300. Steam turbines with double-reduction and single-reduction gearing, and two oil-burning water-tube boilers. Launch, December 21.

M.S. "BRITISH GUNNER."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 490 ft. between perpendiculars by 65 ft. by 36 ft.; deadweight capacity, about 14,000 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Launch, December 22.

M.S. "LYCAON."—Single-screw passenger and cargo vessel, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for Alfred Holt and Co., Liverpool. Main dimensions: 487 ft. overall by 62 ft. by 35 ft. 3 in.; deadweight capacity, about 9,000 tons on a draught of 28 ft.; gross tonnage, about 7,800. Kincaid-B. & W. seven-cylinder Diesel engine, developing 7,000 b.h.p., constructed by John G. Kincaid and Co., Ltd., Greenock, and installed by the shipbuilders. Service speed, 15½ knots. Launch, December 30.

No. 237.—Single-screw oil tanker, built by John Crown and Sons, Ltd., Sunderland, built for Rolf Wigand Skipsrederi, Bergen, Norway. Forward part of vessel constructed and launched; to be attached later to after end in dry dock. Main dimensions: 516 ft. between perpendiculars by 73 ft. by 41 ft. 1 in.; deadweight capacity, about 18,250 tons on a draught of 30 ft. 6 in. Sulzer nine-cylinder single-acting two-stroke oil engine, developing 6,300 b.h.p. at 125 r.p.m. in service, installed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Launch, January 5.

M.S. "ADJUTANT."—Single-screw cargo vessel, built by S. P. Austin and Son, Ltd., Sunderland, for the General Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 246 ft. by 40 ft. by 15 ft. 3 in. to upper deck; deadweight capacity, 1,400 tons. Sulzer six-cylinder single-acting two-stroke Diesel engine, developing 1,800 b.h.p. at 225 r.p.m. Launch, January 5.

M.S. "WHAKATANE."—Single-screw cargo vessel with accommodation for six passengers, built by Alexander Stephen and Sons, Ltd., Linthouse, Glasgow, for the New Zealand Shipping Co., Ltd., London, E.C.3. Main dimensions: 439 ft. 4 in. between perpendiculars by 62 ft. 9 in. by 39 ft. 6 in.; gross tonnage, 8,500; general cargo space, 303,000 cub. ft. Doxford six-cylinder oil engine. Speed, 16 knots. Launch, January 6.

# EVOLUTION OF REINFORCED CONCRETE*

*By W. R. Howard*, F.S.E., M.I.STRUCT.E., M.SOC.C.E.

The development of civilisation has been greatly influenced by the materials at man's disposal and by the availability of the tools for working these materials, first wood then stone, followed by bronze and iron, and so on to the materials of the modern world. Practically coinciding with the formation of the Society of Engineers in 1854, a new engineering age was born, that of ferro-concrete.

From early times, the Romans had used bronze and iron rods to reinforce the roof of the Frigidarium of the Baths of Caracalla. Some 1,500 years later Sir Christopher Wren had chains embedded in the concrete of the dome of St. Paul's Cathedral to resist the lateral thrusts. In this way a new technique was created, so permitting the further development of architectural structures. By the addition of reinforcement in the vertical plane, further developments became possible, and thus, in the eighteenth century, the great church of Ste. Geneviève, which became the Panthéon, was constructed in Paris.

Smeaton, however, discovered that varying percentages of clayey matters are mixed with limestone rocks and influence the behaviour of the calcined lime, and in 1791, in his "Narrative of the Building of the Eddystone Lighthouse," Smeaton described the experiments he had made from 1756 onwards, and it is these investigations which no doubt paved the way for the improvements in limes and cements.

There is a record of a patent granted in 1791 to James Parker to employ "a certain material never before made use of" for "burning bricks and tiles and calcining chalk, earth, stone and limestone," and a further patent was granted in 1796 covering an invention of "a certain cement or trass to be used in aquatic and other buildings and stucco work." Further quick-setting cements, developed on the Continent, were those of Pouilly in 1829, and Vassy in 1831, and in 1818 Vicat published his "Recherches Expérimentales sur les Chaux de Construction, les Bétons et les Mortiers Ordinaires."

In 1822, James Frost specified "a new cement or artificial stone," and he took out a further patent in 1823. Very shortly afterwards, in 1825, Frost established cement works at Swanscombe and became the first maker of artificial cement produced adjacent to London. Prior to this date, however, one finds a patent specification dated October 21, 1824, in which Mr. Joseph Aspdin, a Leeds bricklayer, under the title "An Improvement in the Modes of Producting an Artificial Stone," describes a material to be called Portland Cement. In France, during the nineteenth century, two French scientists, Vicat and Le Chatelier, developed the technical possibilities of the new material and thus at the middle of the nineteenth century all the conditions necessary for the birth of ferro-concrete existed. In 1852, Coignet, a French engineer and contractor, constructed some terrace work at St. Denis, consisting of iron joists surrounded by concrete, and used a similar method in the construction of apartment buildings, and at the same time the Germans were making strides in the use of the new material under the title "Monierbau."

The present year may be regarded as the centenary of ferro-concrete as far as Britain is concerned, The first patent appears to have been taken out in 1854, on October 27, by William Boutland Wilkinson, a plasterer of Newcastle-on-Tyne, probably associated with Joseph Aspdin, who had established a cement factory at Gateshead two years before. Wilkinson's patent proposed the construction of fireproof floors, both arched and flat, reinforced by either flat iron bars placed on edge or by secondhand wire rope. He also described and illustrated independent beams of reinforced concrete, and the methods he employed showed a grasp of most of the principles of present-day construction.

It was towards the end of the nineteenth century that Francois Hennebique, in France, made a series of developments beginning with the use of stirrups to reinforce beams against shear, and earned recognition, with Coignet's son Edmund, as the "Pioneers of the modern evolution in the art of building." Edmund Coignet, for example, on March 1, 1889, presented at a meeting held at the Société des Ingénieurs Civils de France, the first communication dealing with the new material, and during 1896-1900 Louis Considère published the results of his experiments and investigations into the use of ferro-concrete, and in particular his invention relating to hooped concrete.

In 1896 Mr. L. G. Mouchel commenced the development in Britain of the Mouchel Hennebique system of ferro-concrete, the first structures erected entirely in this material being the flour mill and granary at Swansea, followed by an oil mill building at Liverpool, and a river retaining wall at Southampton. The first ferro-concrete jetty in the United Kingdom was built at Woolston, near Southampton, in 1899. Ferro-concrete bridges were built in Hampshire in 1900 and in Lancashire in 1902.

The earliest record of a bridge built in this material is, however, a small footbridge of 15-m. span constructed in France in 1897. This was followed by a bridge at Perpignan, and in 1902 by a bowstring bridge in Paris. In 1898 a bridge of some 43-m. span was constructed over the Steyr in Austria, and at Chatellerault in France between 1898 and 1900 there was built the largest ferro-concrete bridge of that time, which had three arches, the centre arch having a span of 172 ft., and a rise of 17 ft. 6 in., say, 10 per cent. of the span. In those days the adoption of ferro-concrete for such a bridge was considered somewhat daring. In Germany the Monier patents were first granted in 1884, and the well-known engineer, Emperger, published a report detailing the uses of ferro-concrete in the Great Exhibition of 1900 in Austria.

### ACCEPTANCE BY PUBLIC AUTHORITIES

It must be stated that in the early days public authorities were not enthusiastic in supporting the development of the new system of construction. The more important the authorities, the more rigid were their rules and regulations, and accordingly the first structures were for private concerns rather than public authorities. Thanks, however, to the progress made in France and elsewhere, the new material was used more and more by public authorities in this country.

On October 20, 1906, a French Ministerial circular was published which regulated the adoption of ferro-concrete in France, while in 1907 a report by a Joint Committee constituted by the Royal Institute of British Architects was published in Great Britain. The chairman of this Joint Committee was Sir Henry Tanner, F.R.I.B.A., President of the Concrete Institute which was founded in 1908 and is now known as the Institution of Structural Engineers. The vice-chairman was Professor W. C. Unwin, President of the Institution of Civil Engineers. A second report by the same committee was issued in 1911 and was followed by the regulations of the London County Council published in 1915. While these regulations applied to the design of structures to be built within the County area, many of the other large Corporations of Great Britain, not having any by-laws applicable to ferro-concrete work, adopted the regulations of the London County Council.

With the publication of these rules or Codes of Practice, the use of ferro-concrete developed very quickly, and large numbers of bridges, buildings, factories, workshops, warehouse buildings, reservoirs, jetties, wharves, tanks, granaries, garages, barrages and cooling towers were built.

* Centenary Presidential Address to the Society of Engineers, entitled "The Evolution of Ferro-Concrete" and delivered on February 1, 1954. Abridged. See also Weekly Survey, last week, page 162.

# DIESEL PASSENGER UNITS FOR BRITISH RAILWAYS

## MULTIPLE-UNIT LIGHT-WEIGHT TRAINS FOR SIX AREAS

The British Transport Commission have decided to inaugurate passenger services, using multiple-unit light-weight Diesel trains, in Lincolnshire, East Anglia, between Newcastle and Middlesbrough and between Edinburgh and Glasgow. These services will be additional to those which, as already announced, are to be established in the West Riding of Yorkshire and in West Cumberland. All four of the latest schemes will be partly in substitution for, and partly in addition, to the existing steam services. It is hoped in this way to provide better facilities and thus to increase traffic owing to the greater economy and flexibility of Diesel rail-cars.

### CONSTRUCTIONAL ARRANGEMENTS.

The eight two-car units which will be required for the West Riding, as well as the 13 units for West Cumberland and the same number for Lincolnshire, are being built at the Derby works of the London Midland Region, although the engines will be supplied by contractors. Those for the West Riding are expected to be ready about the end of April and those for West Cumberland in the autumn. Arrangements are also being made for the production of 13 two-car units for East Anglia and 10 motor vehicles and 10 trailers for the Newcastle-Middlesbrough services, as well as for six multiple-unit trains and eight spare vehicles for the Edinburgh-Glasgow line.

Except on the Edinburgh-Glasgow service, each unit will consist of two coaches, both of which will be equipped with two engines of a capacity of at least 125 h.p. each. These engines will be installed under the floor. Alternatively, the trains will be made up of one motor coach and one trailer. It will be possible to drive each unit, the seating capacity of which will be about 130 passengers, from either end or to couple it to other units, according to traffic requirements. The units for the Edinburgh-Glasgow lines will incorporate buffet cars and may be regarded as prototypes for the development of rolling stock suitable for fast and relatively light inter-city services.

## Book Reviews

**Measurement Techniques in Mechanical Engineering.** By R. J. SWEENEY. *John Wiley and Sons, Incorporated*, 440, *Fourth-avenue, New York* 16, *U.S.A.* (5·50 dols.) *Chapman and Hall, Limited*, 37, *Essex-street, London, W.C.2.* (44*s.* net.).

It is well to make clear at the outset that Mr. Sweeney's book is a review of typical standard instruments used by mechanical engineers, rather than an account of measurement techniques for elaborate problems, and of the considerations dictating preferred assemblies of apparatus and methods of combining and using instruments over a wide range of experimental engineering. The scope is, in fact, largely restricted to the details of physical measurement entailed in fairly straightforward performance trials of the simpler types of power plant. The basic physical quantities – length, mass, time and temperature – and derived quantities such as force, power, pressure and rate of fluid flow, are successively considered, briefly with respect to engineering units and standards, and at greater length with regard to a representative selection of appropriate measuring instruments. Electrical, including one or two examples of electronic, measurements are treated in the same, somewhat elementary, style, while chapters dealing with the calorimetry of steam and fuels, and with the chemical analysis of fuels and flue-gases are relevant to the testing of thermodynamic prime movers. The author concludes his book with a brief survey of items of mechanical equipment for automatic control systems that may with advantage be employed in certain types of power plant investigations.

Mr. Sweeney's experience in testing naval machinery, and in teaching, is reflected in the material of his book and its mode of presentation, which are suited to students engaged on a traditional laboratory course in mechanical engineering. Even this class of reader may be disappointed that no attempt has been made to give detailed descriptions of instruments of modern design, and that several important and widely-used branches of instrumentation are barely mentioned or wholly omitted. Qualified engineers and research workers who may use the book as a source of reference or suggestion will approve the attention that Mr. Sweeney has given to the sources of instrumental errors and methods of correction, but they are likely to feel that the degree of accuracy attainable in various fields of experimental mechanical engineering has been left regrettably uncertain.

**Tables of $10^x$ (Antilogarithms to the Base 10).** National Bureau of Standards Applied Mathematics, Series No. 27. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (3·50 dols.)

This volume was prepared from a photographed copy of J. Dodson's Antilogarithmic Canon (London 1742) giving antilogarithms to the base 10 to ten decimal places (11 significant figures) at intervals of 0·00001 employing international Business Machine equipment. The ten decimal place values with their arguments were transferred to cards and differenced with the aid of a tabulator. The resulting differences were examined for errors and about 250 major errors corrected. After an additional summation check the final printed table was differenced on a Sunstrand class D machine which listed the argument, entry, first, second and third differences, all of which were carefully inspected for errors.

The entries in Table I of the present volume giving $10^x$ for $x = 0$ (·00001) 1·00000, 10 D read vertically instead of horizontally as in Dodson's table. Differences and proportional parts are not necessary due to the ease of performing linear interpolation by machine which will ensure nine decimal place accuracy. For full ten decimal accuracy the linear interpolation is followed by a slight correction obtained by subtracting $C(p)$ which does not exceed seven units in the last place and the actual value which is read off from the schedule given in the introduction by Herbert E. Salzer. Table II of $10^{n \times 10^{-p}}$; $n = 1$ (1) 999; $p = 3, 6, 9, 12, 15$; 15 D enables one to obtain in a few steps the antilogarithm of any 15 decimal number to about 15 significant figures. This number N, being written in the form $N = n_1\,10^{-3} + n_2\,10^{-6} + n_3\,10^{-9} + n_4\,10^{-12} + n_5\,10^{-15}$ where $n_i, i = 1(1) 5$, is a positive integer not exceeding 999, the antilogarithm of N can be found from its factors $10^{n \times 10^{-3}}, 10^{n \times 10^{-6}} \ldots 10^{n \times 10^{-15}}$: where $n$ ranges over the integers from 1 to 999, the values of which are extracted from the table. The computational work is considerably curtailed if fewer decimals are required in the result or if the argument has fewer decimals. A method of finding logarithms as well as antilogarithms from this radix table is explained and is quite practical if the logarithm is desired to nine places or under, for then it does not require more than two divisions each involving numbers of ten or fewer significant figures.

This handsomely produced and moderately priced 550 page volume meets all the demands for a standard table of antilogarithms to the base 10.

**Winter Concreting.** By P. NERENST, E. RASTRUP AND G. M. IDORN. The Danish National Institute of Building Research, Copenhagen. (Kr. 8).

This is an abbreviated English translation of the text of *Betonstøbning om Vinteren*, Publication No. 17 of the Danish National Institute of Building Research. The translation has to be read in conjunction with the original, which is supplied with the translation, as the illustrations have not been reproduced.

The report is based on extensive experiments conducted both in the United States and at the National Institute in Copenhagen. It is recommended that air-entrainment should be adopted to achieve resistance to freezing by the concrete while hardening after only a brief period of protection. Time-temperature relationships have been established which enable the rate of hydration at any prevailing temperature to be expressed as a hydration period at a given temperature so that an accurate assessment can be made of the period which must elapse before shuttering may be safely struck. The same time-temperature function together with the figures given for the generation of the heat of hydration make it possible to predict the temperatures of concrete members throughout the period of hardening.

Data are given for several different combinations of types of cement, initial temperatures, types of insulation, etc., so that it will be of value to contractors concerned with placing concrete during winter.

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## Trade Publications

**American Logging Equipment.** The Hyster Company, Portland 8, Oregon, U.S.A., have sent us a brochure describing and illustrating their range of logging equipment and land-clearing tackle, which includes skid-pans, chokers, logging arches, and a variety of hooks, pulleys, swivels and quick-acting connectors.

**Pistons and Piston Rings.** A brochure which outlines the growth of Wellworthy, Ltd., Lymington, Hampshire, and gives some details of the company's present activities has been received from them. This company, which started with the production of piston rings 35 years ago, now produces pistons, cylinder liners and aero-engine castings, besides a variety of other components. They have factories situated at Ringwood and Salisbury apart from their Radial and Ampress works at Lymington, of which the former is the head office.

**Pulveriser.** An illustrated leaflet, published by International Combustion Ltd., 19, Woburn-place, London, W.C.1, describes the construction, operation and scope of the Raymond screen pulveriser, which is designed to deal chiefly with clays and talcs. A table giving operating results with materials ranging from soft coal to dry colour and numerous other substances is included. A second publication from the same company treats similarly their Number "0" Raymond lime conditioner and Number "00" Raymond pulveriser.

**Engineers' and Saw Files.** Details of engineers' files and saw files are given in an illustrated booklet issued by Sanderson Brothers & Newbould Ltd., Attercliffe Steel Works, Sheffield. The applications and type of cut or surface appropriate to each size and pattern of file are listed and, as a guide, various standard cuts are illustrated full size.

**Woodworking Machinery.** A range of woodworking machines which include band saws, planers, saw-sharpening machines and an electric dovetailer for preparing the ends of wooden beer crates and similar boxes are illustrated in a thumb-indexed catalogue sent to us by Thomas Robinson & Son, Ltd., Railway Works, Rochdale, Lancashire.

**Slip Gauges.** Tables giving details of five sets of slip gauges made in accordance with B.S.S. 888 and issued in four grades are contained in a leaflet published by the Farno Engineering Co., Ltd., Metrology Division, 11, Rope Yard Rails, London, S.E.18. The maximum possible errors, in units of one millionth of an inch, for length, flatness and parallelism are recorded and are, on a one inch length in calibration grade, for example, 5, 3 and 3 units, respectively.

**Precision Electrical Instruments.** A leaflet issued by the Croydon Precision Instrument Co., Ltd., 116, Windmill-road, Croydon, Surrey, describes some of their electrical measuring instruments. Included are resistance bridges, and boxes, standard resistances with high dissipation and a tuning fork which is accurate to within 0·02 per cent.

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## Books Received

**Galvanizing Techniques in the U.S.A.** *Organisation for European Economic Co-operation*, 2, *Rue André-Pascal, Paris* (16*e.*); and *H.M. Stationery Office, Kingsway, London, W.C.2.* (9*s.*)

**Report on the Atom.** What you Should Know about Atomic Energy. By GORDON DEAN. *Eyre and Spottiswoode Limited*, 15, *Bedford-street, London, W.C.2.* (16*s.* net.)

**Modern Electroplating.** Edited by ALLEN G. GRAY. *John Wiley and Sons, Incorporated*, 440, *Fourth-avenue, New York* 16, *U.S.A.* (8·50 dols.); and *Chapman and Hall, Limited*, 37, *Essex-street, London, W.C.2.* (68*s.* net.)

**Routing.** By A. H. HAYCOCK. *The Technical Press Limited, Gloucester-road, Kingston Hill, Surrey.* (10*s.* 6*d.*)

**Electrical Engineering for Mining Students.** By G. M. HARVEY. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (15*s.* net.)

**Industrial Training for Manual Operations.** By W. DOUGLAS SEYMOUR. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (20*s.* net.)

**Non-Ferrous Foundry Metallurgy.** By PROFESSOR A. J. MURPHY. *Pergamon Press Limited*, 242, *Marylebone-road, London, N.W.1.* (70*s.* net.)

**Ångtabeller. Thermodynamic Tables in the Metric System for Water and Steam.** Calculated under the guidance of PROFESSOR O. H. FAXÉN. Forskning och Teknik, No. 2. *Nordisk Rotogravyr, Stockholm, Sweden.* (19 Swedish kroner.)

**Technische Kompositionslehre.** By DR. FRITZ KESSELRING. *Springer-Verlag, Reichpietschufer* 20, *Berlin W.* 35. (39 D.M.)

**Lloyd's Register of Shipping.** Register Book Appendix, 1954. *Offices of the Register*, 71, *Fenchurch-street, London, E.C.3.*

**Introduction to Ultra-High-Frequency Radio Engineering.** By STEPHEN A. KNIGHT. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (21*s.* net.)

**High Voltage Laboratory Technique.** By J. D. CRAGGS and J. M. MEEK. *Butterworths Scientific Publications*, 88, *Kingsway, London, W.C.2.* (65*s.* net.)

**Analysis of Deformation.** By DR. KEITH SWAINGER. Vol. 1. Mathematical Theory. *Chapman and Hall, Limited*, 37, *Essex-street, London, W.C.2.* (63*s.* net.)

**The Use of Aircraft in Agriculture in the U.S.A.** *Organisation for European Economic Co-operation*, 2, *Rue André Pascal, Paris* (16*e*). (300 francs), and *H.M. Stationery Office, Kingsway, London, W.C.2.* (6*s.*)

**Mathematics for Students of Engineering and Applied Science.** By L. B. BENNY. *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.4.* (35*s.* net.)

*The Engineering Outlook—6*

# TEXTILE MACHINERY

## RESEARCH, DESIGN AND COSTS

MANY sections of the engineering industry are now facing difficult sales problems but few are quite so grave or so urgent as those confronting the manufacturers of textile machinery. Orders have been falling for the past two or three years for most of the traditional types of textile machinery, although output continued to increase until 1952, when it reached record levels. As may be seen from the graphs below, the fall in orders had begun to affect output in 1953, when only jute and flax processing machinery, and hosiery and knitting machinery, escaped the downward trend. This became more accentuated throughout 1953, as may be seen from the graphs opposite, which show quarterly output. The low level of orders reflects the recent recession in 1952, and may be expected to improve somewhat if the recovery in demand for textiles is sustained, but foreign competition is now very keen overseas, and at home there is little assurance that, despite the urgent need for re-equipment, the textile industries will greatly increase their scale of purchases. The development of trade with China and Russia would, of course, greatly change the outlook, and the recent announcement of a large order from Russia is a hopeful sign. Heavy expenditure by the Government of Pakistan on the establishment of a jute textile industry has meant full order books for makers of jute machinery, but the demand has been weakening lately. This is also true of hosiery and knitting machinery, for which, until recently, deliveries were very extended.

### CHANGING MARKETS AND JAPANESE COMPETITION

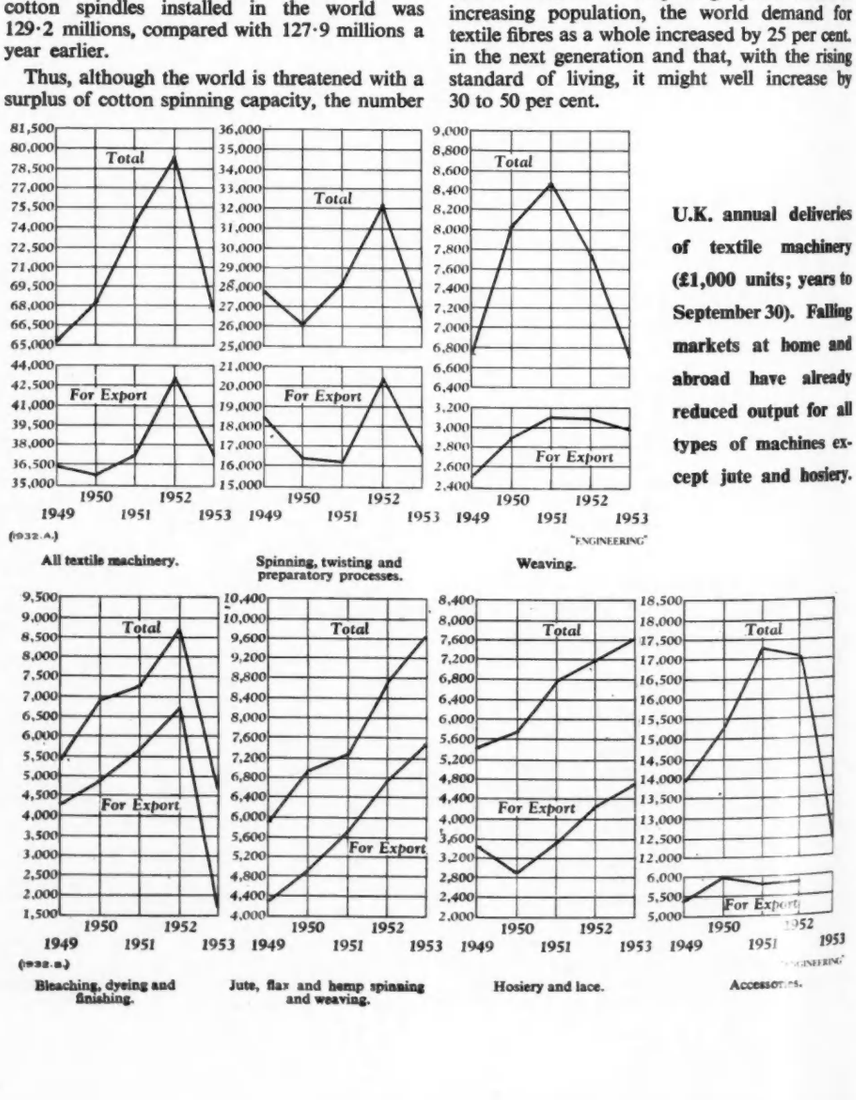
Makers of machinery for the cotton textile industry have the most intractable sales problem. There are, of course, still large orders on hand for some types of modern machinery and equipment, which continue to supplant more traditional types; the output of automatic looms, for example, should be maintained, although the total output of weaving machinery has already fallen off. Many types of high-speed winding machinery which offer large savings in process costs are also in keen demand. Machinery for spinning, twisting and preparatory processes, the output and exports of which are considerably greater than for any other category of textile machinery, is the most seriously affected by falling demand; if large orders are not received in the next few months manufacturers may have to pay off many of their workpeople. Many influences have combined to bring about a drastic reduction in demand, some of which derive from far-reaching changes in the cotton textile industries of the world. The world consumption of cotton is now about one-quarter greater than before the war, but international trade in cotton textiles is now only about 5,000 million yards per annum compared with about 7,000 millions before the war.

Large cotton textile industries have grown up over the years in the Americas, Western Europe and India. Some, now that the Japanese manufacturers have again resumed their position as the leading exporters of low-priced cottons, are finding it difficult to maintain economic production.

At the end of 1953, three cotton mills had to be shut down in Canada, and in the Italian cotton spinning industry, which only exported 28 million lb. of yarn in 1953 compared with an average of 59 million lb. for the three years 1949 to 1951, nearly one-fifth of the 5·8 million spinning spindles in place are idle. The Japanese cotton industry, on the other hand, continues to grow. In their latest quarterly statistical review, the Cotton Board point out that, while world trade in the third quarter of 1953 was only 1 per cent. higher than in the preceding quarter, the Japanese had increased their exports of cotton cloth from 206 to 242 million square yards. The number of spindles installed in Japan increased by 500,000 in the six months to January, 1953, although the world demand for textiles at this time was at a very low level. In Pakistan, in the same period, the number of spindles increased by 200,000, the number installed in India increased by 186,000, and at the end of January, 1953, the total number of cotton spindles installed in the world was 129·2 millions, compared with 127·9 millions a year earlier.

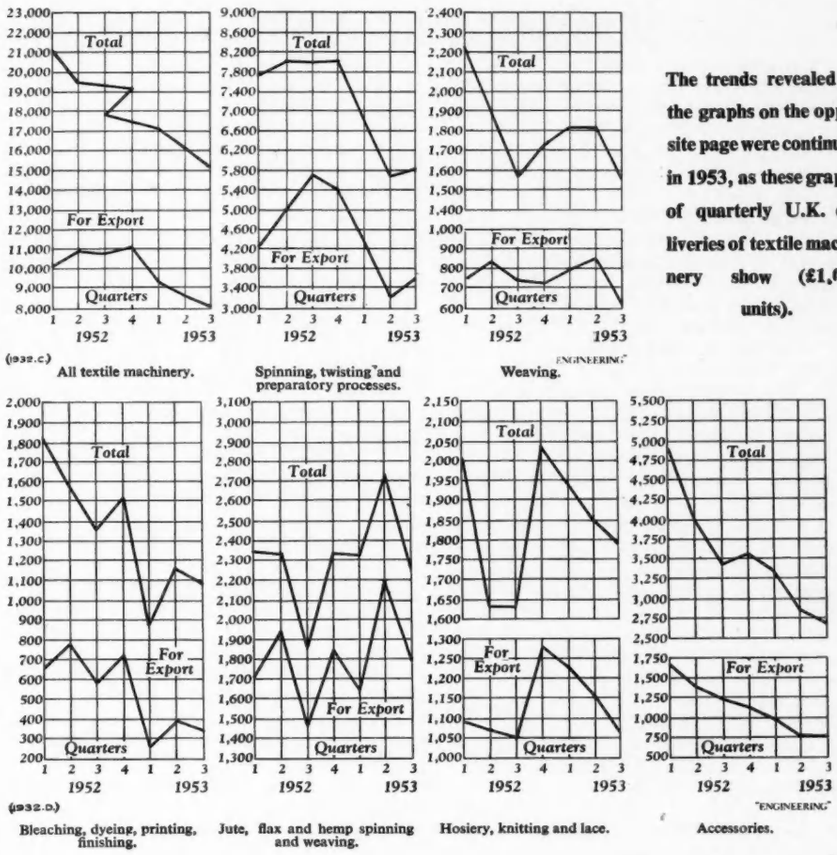
Thus, although the world is threatened with a surplus of cotton spinning capacity, the number of spindles continues to increase in the far Eastern countries, where labour costs are very low. These are the countries which are likely to be attracted more by the cheapness of new spinning machinery offered to them than by quality, and consequently are likely to buy from Japanese manufacturers, who are said to be quoting prices up to 40 per cent. less than the British. The only other textile-machinery markets which are expanding capacity, and in which British manufacturers could expect to make headway, are those of South America, particularly Brazil. Currency difficulties have eased a little, but Brazil is likely to be short of sterling for a long time yet, and the declining trend of exports shown in Table I, taken from the *Trade and Navigation Accounts*, may be expected to continue. The number of spindles installed in North America and in Europe has already begun to fall off. In the six months to January, 1953, the European total fell by nearly 800,000 and the number installed in North America by 159,000.

Competition from other fibres is, to some extent, limiting the demand for cotton, but 72 per cent. of the world clothing material is still made of cotton and, though this proportion may be expected to fall considerably over the next few years, it need not necessarily mean a contraction in the total demand for cotton. In any case, it will affect Lancashire and British makers of textile machinery only in so far as they will have to devote more attention to the utilisation of the new fibres. Professor A. J. Brown, head of the Department of Economics and Commerce at Leeds University, has said that it would not be surprising if, as a result of increasing population, the world demand for textile fibres as a whole increased by 25 per cent. in the next generation and that, with the rising standard of living, it might well increase by 30 to 50 per cent.




**U.K. annual deliveries of textile machinery (£1,000 units; years to September 30). Falling markets at home and abroad have already reduced output for all types of machines except jute and hosiery.**

Much of the new demand will come from the under-developed territories in Africa and the Far East, and will probably mean further expansion in demand for Japanese and Indian textiles at the expense of European and American. It may be accompanied, however, by a demand for higher-quality cottons, which will help to maintain output and employment in Lancashire. The African markets have been the object of special study by teams from the Lancashire cotton industry in 1953. Imports of Japanese textiles into many African territories are at present restricted, but, since the needs of the poorer African for low-quality textiles can be most effectively met by low-cost Japanese producers, it will not be practicable to exclude them from British colonial markets indefinitely. Relaxation of import restrictions was promised under the recent Anglo-Japanese Payments Agreement and a partial removal of the embargo in certain classes of Japanese textiles will be effective from May 1, 1954. To maintain trade in these territories, the Lancashire cotton industry will have to concentrate, therefore, on developing the demand for goods of higher quality. The leader of the textile team which visited East Africa in 1953 has stated that much information has been gained about the types and qualities of cotton required, and that one of the recommendations of the team is that experiments should be conducted with a particular cloth which should be sold as a branded article to East African customers.




**The trends revealed by the graphs on the opposite page were continued in 1953, as these graphs of quarterly U.K. deliveries of textile machinery show (£1,000 units).**

## MACHINERY AND PRODUCTIVITY

The future prosperity of the Lancashire cotton industry will depend more and more upon the ability to increase efficiency and keep down prices in world markets. It is not too healthy a sign that the present recovery has been based more upon improvement in home than in export demand, although exports have been rising and are now about 80 per cent. of the average for 1950 to 1951.

So far, the progress made in raising productivity has not been encouraging. Sir Raymond Street, speaking at the annual conference of the cotton textile industry in Harrogate in October, pointed out that, between 1947 and 1951, the output per worker in the spinning section rose by 6·3 per cent. gross, but, after allowing for changes in the average counts of yarn produced, the net increase was probably only 3·7 per cent.; in the weaving section the improvement was no more remarkable. This is due at least partly to inadequate investment in new plant and machinery, although other factors, notably the attitude of organised labour to " redeployment " and shift-working, are also important. A census of machinery made by the International Federation of Cotton Spinners' Association shows that, due to double and sometimes treble shift-working in many countries, the increased post-war output of cotton textiles has been obtained from fewer looms and spindles. The number of power looms installed in the world has fallen from 3·1 millions in 1936 to 2·7 millions in 1952, or by 11 per cent. The number of spinning spindles fell by 16 per cent. to 128 millions in 1952, though the consumption of cotton had increased by 25 per cent. A census of hours worked in the cotton industries in 37 countries shows that fewer hours were worked per spindle in Lancashire than in any other cotton industry. The census was taken during a period of depression, and the Lancashire figure is unduly low; nevertheless, the comparison is instructive. The number of hours worked per spindle in Japan was 1,799, compared with 2,727 for the United States, an average of about 1,400 hours for Continental European countries, and 718 for Lancashire.

To all the other difficulties in the way of the acceptance of shift-working by cotton operatives, is now added a serious shortage of labour. The recession in 1952 lasted only a few months, but during the course of it the Lancashire cotton industry lost 58,000 operatives and, because of a lack of confidence in the industry's future, only about one-third of these returned after the recovery. This makes it all the more urgent that the mills should be equipped with the most modern machinery. Mr. G. Hasty, President of the Federation of Master Cotton Spinners' Association, said recently that Lancashire had spent more money since the war on new machinery in proportion to the size of its industry than any other European country. This may be true, but the European cotton textile industries are not notably efficient and have already lost

TABLE I.—UNITED KINGDOM: EXPORTS OF TEXTILE MACHINERY, BY COUNTRIES. (January to November)

| | Quantities (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| Textile Machinery: | | | | | | |
| Union of South Africa | 59 | 69 | 52 | 1,182 | 1,440 | 1,251 |
| India | 305 | 395 | 317 | 6,273 | 8,668 | 6,990 |
| Pakistan | 170 | 214 | 194 | 2,152 | 3,189 | 3,309 |
| Hong Kong | 37 | 37 | 19 | 743 | 733 | 476 |
| Australia | 75 | 68 | 55 | 1,697 | 1,783 | 1,614 |
| New Zealand | 14 | 17 | 9 | 351 | 420 | 262 |
| Canada | 60 | 58 | 32 | 1,273 | 1,438 | 1,042 |
| Other Commonwealth Countries | 13 | 26 | 27 | 273 | 513 | 596 |
| Irish Republic | 43 | 25 | 41 | 755 | 478 | 771 |
| Finland | 40 | 24 | 33 | 870 | 613 | 735 |
| Sweden | 53 | 26 | 19 | 1,438 | 813 | 643 |
| Norway | 22 | 18 | 6 | 506 | 462 | 210 |
| Denmark | 14 | 13 | 11 | 360 | 340 | 360 |
| Poland | 25 | 23 | 10 | 480 | 420 | 266 |
| Western Germany | 46 | 54 | 47 | 1,231 | 1,586 | 1,617 |
| Netherlands | 70 | 59 | 47 | 1,553 | 1,309 | 1,180 |
| Belgium | 60 | 61 | 53 | 1,398 | 1,494 | 1,365 |
| France | 129 | 86 | 75 | 3,182 | 2,514 | 2,579 |
| Switzerland | 9 | 8 | 6 | 366 | 368 | 244 |
| Portugal | 47 | 40 | 33 | 806 | 879 | 764 |
| Spain | 5 | 5 | 21 | 160 | 196 | 544 |
| Italy | 99 | 225 | 151 | 1,914 | 4,625 | 3,387 |
| Austria | 21 | 10 | 8 | 452 | 311 | 252 |
| Yugoslavia | 112 | 3 | 3 | 1,810 | 100 | 125 |
| Greece | 25 | 20 | 10 | 508 | 461 | 242 |
| Turkey | 68 | 98 | 34 | 1,192 | 1,982 | 697 |
| Belgian Congo | 11 | 22 | 14 | 175 | 449 | 300 |
| Egypt | 44 | 33 | 21 | 934 | 782 | 523 |
| Iran | 23 | 6 | 5 | 425 | 130 | 109 |
| China | 15 | 22 | 10 | 360 | 498 | 255 |
| Japan | 7 | 17 | 23 | 139 | 430 | 569 |
| United States of America | 52 | 40 | 43 | 1,506 | 1,214 | 1,530 |
| Mexico | 27 | 36 | 33 | 612 | 814 | 809 |
| Peru | 8 | 20 | 10 | 202 | 424 | 259 |
| Chile | 10 | 9 | 6 | 311 | 288 | 166 |
| Brazil | 165 | 265 | 119 | 3,514 | 5,823 | 2,637 |
| Uruguay | 7 | 5 | 2 | 258 | 151 | 87 |
| Argentine Republic | 40 | 24 | 3 | 910 | 722 | 75 |
| Other foreign countries | 71 | 73 | 85 | 1,376 | 1,582 | 1,957 |
| Total | 2,101 | 2,254 | 1,687 | 43,647 | 50,442 | 40,797 |

much ground. The total amount spent on re-equipment by the Lancashire mills between 1947 and 1952 was £28·0 millions for all processes preparatory to weaving, and £14·4 millions for weaving. These figures are disappointingly low, especially when it is remembered that £2·9 millions were paid out by a subsidy under the Cotton Spinning Re-equipment Subsidy Act, 1948.

A total of 26 groups, controlling about 51 per cent. of the cotton-spinning capacity in terms of mule equivalent spindles, eventually registered to take advantage of the scheme, and they submitted plans covering the modernisation of 195 mills and 12 million mule equivalent spindles. The total cost of the modernisation plans, including the Exchequer contribution, was £11·6 millions. Failure to participate in the Cripps scheme, does not, of course, imply that a company did not undertake modernisation on its own account; in many cases, this was more satisfactorily done by adapting existing machinery rather than purchasing completely new plant. Many companies, for example, have converted existing frames to high drafting, and others have been converted for using high package sizes. In weaving, it is not necessarily desirable that the fully automatic should replace the Lancashire loom. Many weavers believe that, in the interests of quality production, to which Lancashire must pay increasing attention, the future lies in the adaptation of Lancashire looms to smoother running and faster working. Nevertheless, there is undoubtedly considerable scope for increasing employment of automatics. Figures recently supplied by the Board of Trade show that at the end of July, 1953, only 34,282 automatic looms were installed, or 10 per cent. of the total looms erected in running mills. This compares with 7 per cent. in 1948 and 3 per cent. in 1936.

## RESEARCH RESULTS NOT APPLIED

It is no fault of the research facilities at its disposal, or of the textile machinery makers, that the Lancashire cotton industry is not equipped with highly efficient machinery. Doubts were recently expressed about the adequacy of the funds available to the Shirley Institute, the headquarters of the British Cotton Industry Research Association. These derive from a levy on the industry and a Government grant which will amount to about £350,000 in 1954. Nevertheless, they may prove barely adequate now that, in addition to its other activities, the Shirley Institute has recently undertaken a programme of comprehensive research into the spinning, weaving and finishing of various blends of natural and synthetic fibres. The challenge of the new fibres is one that is likely to require increasing attention, and, according to Dr. D. W. Hill, of the Research centre, will need new skills and a considerable increase in the scientific and technical personnel of the industry. One of the major difficulties which the Shirley Institute has had to counter in recent years has been that of ensuring that the results of its research work are translated into effective action in the mills. This has been partly due to apathy among the cotton manufacturers, but, in the case of machinery and apparatus, it has been due also to the difficulty in having it produced as a commercial venture. Shirley Developments, Limited, was founded to form the link with commercial producers, and is now actively assisting or sponsoring sales of about 40 inventions.

Many Shirley products are already in every-day use by the cotton industry, including the automatic doffer and automatic size box. The most recent to be introduced, and one which might well justify the label "revolutionary," is an opener for cotton from the bale. This is marketed by Messrs. Tweedale and Smalley (1920), Limited, and was exhibited at the International Exhibition of Textile Machinery in Manchester, organised by *The Textile Recorder* in October. The "opener" is based upon the well-known Shirley analyser for estimating trash and seed in raw cotton samples, which already employs the cleaning principles adopted in the new machine. This is said to have a cleaning power as good as three or four existing types of opener; with an output of 400 lb. an hour it can remove 66 per cent. of the trash with only a 2 per cent. loss of lint. Other machinery on view at the exhibition showed important advances in shorter processing, higher speeds, larger yarn packages and greater automatic control. Not all of the notable new designs were British, for, in addition to other European manufacturers, the Germans were exhibiting for the first time since 1936. Perhaps the most notable European contributions were two machines for the short processing of synthetic fibres. These take the tow of continuous filament straight from the producing machine, cut or break it into staple fibre lengths, and spin it into yarn. These machines, and the American "Pacific Converter," of similar conception, offer large savings in process costs compared with the normal practice of baling the staple fibre for despatch to the cotton mills for spinning on conventional machinery.

Textile Machinery Makers, Limited, who have their own research station at Helmshore, have also done much work on the processes up to the spinning of staple, but equally significant was machinery they exhibited for mixing fibres of different kinds in the requisite proportions to impart the required characteristics to a given fabric. The new T.M.M. process ensures blending to a margin of error of less than 1 per cent. Machinery which can greatly reduce production costs and keep the British textile industries technologically ahead of their rivals is thus readily available.

## HIGH OUTPUT OF JUTE MACHINERY

One of the British textile industries which has considerably increased the *tempo* of re-equipment in recent years is the jute industry, although there has lately been some slowing up of inquiries. Nevertheless, the jute industry has devoted about £6 millions to modernisation since the war, and an outlay of about £700,000 on spinning machinery during 1953 was nearly twice the average for 1951 and 1952. At the end of 1953 still only a quarter of the looms installed were automatic, but this compares with one-seventh at the end of 1952. Despite their high volume, home sales account for only a small proportion of the total turnover of the makers of jute machinery. By far the most important market is Pakistan, the third largest market for textile machinery. In addition to a large jute industry, Pakistan has been building up a new cotton industry, and British manufacturers of machinery for both fibres have received considerable orders, though some important orders for cotton machinery have been lost to the Japanese. The production of jute goods in Pakistan is now at the rate of 110,000 tons a year. By the end of 1954, eleven jute mills with 6,250 looms should be in operation, carrying production to 200,000 tons per annum. By the end of 1955, three more mills will go into production. Orders for machinery for these mills have already been placed, but Pakistan is likely to continue to be an important market for jute machinery for a long time.

The demand for machinery for the linen industry has been less strong than for the jute; in a period of difficult trading, manufacturers in Scotland and Ireland have been prone to conserve their capital, although in Ireland help has been forthcoming for re-equipment schemes through the Re-equipment of Industry Acts. Nevertheless, more automatic looms are being installed, and high-speed precision winders are replacing older types. Considerable purchase of modern types of spinning and preparatory machinery were also made, and further molten-metal dyeing units were installed by the finishing section. The Standfast molten-metal continuous dyeing process, which enables exact and uniform shades to be dyed on long runs at speeds as high as 60 yards a minute, has found ready acceptance throughout the textile industries. The demand for bleaching, dyeing and finishing machinery as a whole, however, has been falling; the value of output in 1953 was only about three-quarters of the total for 1952, and there is little prospect of improvement in 1954.

## IMPORT LICENCES RESTRICTED

The output of hosiery and knitting machinery increased in 1953, but, despite the return of prosperity to the hosiery industries, the demand has weakened lately. This is somewhat disappointing, since machinery manufacturers have developed new machines and greatly expanded capacity in order to obviate the necessity of importing on a large scale, from the United States, expensive fully-fashioned machines. Imports were still at a high level in 1953, when United States manufacturers supplied hosiery machinery valued at £2·0 millions out of a total of £2·1 millions purchased abroad. Altogether about 200 fully-fashioned machines have been imported from the United States in the past two years. The President of the Board of Trade announced in June, however, that only a limited number of licences would be issued in 1954. He said that fully-fashioned hosiery machinery was available in certain non-dollar countries as well as in the United Kingdom, and might be imported from these sources under open general licence. He did not accept the implication that the use of American machines would make nylon stockings more durable, and he was not satisfied that the expenditure of more dollars than were already being provided would give a compensating increase in exports of stockings.

However high, there is still room for considerable improvement in the standard of equipment in the British hosiery industry; it is, therefore, unfortunate that the Hosiery and Allied Trades Association has been meeting with so little support. The Association has now been operating for four years, but has been finding some difficulty in providing finance for its second five-year period, which starts in July. Mr. S. F. Peshall, the chairman, has said that, in a recent referendum sent out to 1,100 hosiery manufacturers, dyers and finishers, asking whether they were prepared to support either voluntary or statutory methods of subscription to the Research Association, only 405 replies had been received. In an industry in which there has been rapid technical advance and considerable expansion of capacity in recent years, permanent research facilities similar to those provided by the Shirley Institute or the Wool Industries Research Association could play a very important part, and it is to be hoped that the apathy of so many of the members of the industry will be overcome before it is too late.

Fortunately, research by the individual makers of hosiery machinery has been particularly fruitful in recent years, and the new products have opened up important export markets. Before the war, the manufacture of warp-knitting machines was mainly in the hands of the Germans and, by the outbreak of war in 1939, they were marketing bearded-needle knitting machines which achieved speeds of 450 to 500 courses a

TABLE II.—UNITED KINGDOM: EXPORTS OF TEXTILE MACHINERY, BY MAIN MACHINERY GROUPS. (January to November)

| | Quantities (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| *New:* | | | | | | |
| For making synthetic fibres | 52 | 64 | 23 | 1,329 | 1,624 | 707 |
| For spinning and twisting and all preparatory processes | 1,122 | 1,297 | 931 | 20,848 | 26,711 | 20,748 |
| For processes preparatory to weaving, but subsequent to spinning and twisting | 67 | 61 | 48 | 1,651 | 1,489 | 1,329 |
| Looms and other weaving machinery | 362 | 358 | 307 | 5,402 | 5,683 | 5,268 |
| Bleaching, dyeing, printing and other finishing | 151 | 136 | 111 | 3,002 | 3,098 | 2,731 |
| Hosiery and other knitting | 48 | 50 | 47 | 3,921 | 4,411 | 4,620 |
| All other textile machinery | 65 | 66 | 74 | 1,599 | 1,807 | 2,082 |
| *Accessories*, separately consigned: | | | | | | |
| Bobbins | 13 | 14 | 8 | 538 | 611 | 313 |
| Boxes and cans | 19 | 14 | 12 | 352 | 279 | 203 |
| Card clothing | 42 | 36 | 26 | 2,327 | 2,030 | 1,414 |
| Pirns, cones and tubes | 14 | 13 | 10 | 395 | 340 | 207 |
| Reeds and healds | 17 | 13 | 5 | 593 | 504 | 207 |
| Shuttles | 13 | 11 | 4 | 716 | 678 | 215 |
| Second-hand | 116 | 121 | 81 | 974 | 1,177 | 753 |
| Total | 2,101 | 2,254 | 1,687 | 43,647 | 50,442 | 40,797 |

minute. British manufacturers, who did not enter the field until the immediate pre-war years, are now marketing a warp knitter of original design which can achieve a speed under mill conditions of 1,000 courses a minute. The development of this machine was carefully planned by F.N.F., Limited, formed as a joint venture by Courtaulds, Limited, and Morton and Sundour Fabrics, Limited. In addition to their own resources, the research team were able to look to the Engineering Department of the University of Bristol for advice. Another company whose products have found wide acceptance at home and abroad is Mellor Bromley and Company, Limited, who probably make a greater range of circular knitting machines than any other manufacturer in the world. They are pre-eminent as manufacturers of interlock machines, in the design of which important advances have been made in recent years.

Other companies which have made considerable progress are the Bentley Engineering Group, who have a new outer-wear fully-fashioning machine, which is attracting considerable attention; and a new company, Hosemaster Machine Company, Limited, who are marketing a fully-fashioned hose-knitting machine with considerable success. Manufacturers of hosiery and knitting machinery have paid considerable attention to developing the United States market, and exports of machinery of this type account for a high proportion of the total British exports of textile machinery of £1·5 millions to the United States in 1953. Despite many encouraging successes, manufacturers in general are finding it increasingly hard to sell overseas; as may be seen from Table II, taken from the *Trade and Navigation Accounts*, the volume of exports of hosiery and machinery was rather lower in 1953 than in 1952, although the value was slightly higher. Nevertheless, the volume of orders should permit exports to be maintained at a high level, though it is more difficult to see further ahead.

### FALLING EXPORTS

The value of exports of all types of textile machinery, shown in Table II, apart from hosiery and a miscellaneous category, fell off considerably in 1953, and in consequence total exports were nearly one-fifth lower than in 1952. In India, which is still the largest market, accounting for 17 per cent. of British exports, the trend would probably continue downward even if Japanese competition were less intense. Accessories are being made in India on a large scale, and there is also a substantial output of spinning and carding machinery and looms. The production of automatic looms is being particularly encouraged. There is undoubtedly considerable scope for re-equipment and re-organisation in the Indian textile industries, but there are considerable financial difficulties to be overcome. The Indian cotton industry, although able to call upon a plentiful supply of cheap labour is not nearly such a low-cost producer as the Japanese. While home demand is likely to increase, it may be very difficult to maintain exports. Indian exports suffered particularly severely in the depression of 1952, and the uncertainty of markets has considerably slowed down the pace of expansion.

The fall in exports to Brazil has been particularly serious for British manufacturers, but nothing short of large sterling loans can rectify matters, and, even if the United Kingdom had the finance available, it is still doubtful whether the risks would be justifiable. In general, textile manufacturers have little cause to complain that they are losing business through inability to offer adequate credit. Where the Export Credits Guarantees Department has been able to cover the risk, manufacturers have had no difficulty in obtaining bank finance; and the E.C.G.D. have always been willing to insure against all reasonable risks.

To the problem of falling demand in European markets is added the danger of excess capacity for many types of equipment. Discussions on the possibility of rationalisation under the auspices of the Organisation for European Economic Co-operation have been going on for some time now; a first report of the O.E.E.C. studies was published in 1952, but this was purely theoretical and concrete action by the participating countries is still a long way off.

Although new export orders were generally scarce in 1953, some important ones were received. Dobson and Barlow, Ltd., for example, are said to have secured a contract valued at £350,000 for rayon-spinning plant for Egypt. The capacity of the plant is to be 7·5 tons of rayon yarn a day, and production in the first section is to start early in 1954. Messrs. Platt Brothers (Sales), Limited, have received an order for cotton spinning machinery valued at £850,000, placed by the Crown Agents for the Colonies, acting on behalf of the United Nations Korean Reconstruction Agency in New York. The contract provides for spinning and winding machinery and accessories for three cotton-spinning mills, totalling 50,000 spindles. The need for rehabilitation is probably nearly as great in the Chinese as in the Korean textile industries, and the re-opening of this market could radically change the outlook of the British textile machinery industry. The possibility of doing business is, however, remote as yet, although there are grounds for hope in the improvement in the political situation. The possibility of trade with Russia has become a reality in recent months. A Russian trade mission recently visited textile-machinery manufacturers in Lancashire and Yorkshire, and a British team of experts is now in Moscow studying Russian requirements in detail.

Apart from the possibility of increased trade with the Communist-controlled countries, the market for many types of textile machinery is at least temporarily depressed. The machinery which the British manufacturers have to offer, however, is the finest in the world, and, though they may have lost ground to competitors who can offer cheaper products in some markets, they can face the future with confidence so long as they maintain their technological lead.

# ELECTROPLATING AND LEAD-PIPE PRODUCTION

## RESEARCH ASSOCIATION'S SERVICE

The application of scientific knowledge and the results of research to industrial production processes has always been one of the leading objects of the British Non-Ferrous Metals Research Association, Euston-street, London, N.W.1, this work being carried out by the Association's liaison and technical service department. This was established originally as the development department.

From the substantial sums of money existing as the sterling counterpart funds, created to balance the dollar funds made available to this country by the United States under the Mutual Security Act of 1952, H.M. Treasury are making grants to finance projects intended to aid the economy of this country by augmenting industrial productivity. In order to enable it to carry out work of this type the Association has received an offer of up to £15,000, to be spent within the next three years. A substantial part of this sum is to be expended in the provision of an advisory service to electroplaters and the remainder will be utilised in providing certain new technical services for the lead-pipe industry.

In the electroplating field, the Association is undertaking a scheme whereby a small team of investigators will visit plating shops by invitation to study methods of working, plant layout and other matters. Observations made in a considerable number of plating shops will be studied, and the conclusions reached affecting matters of good practice in achieving high productivity will be made available to firms engaged in plating, it being emphasised that the sources of information will be known only to the Association's staff. In parallel with this field work, the Association has set up a pilot-scale plating plant operating on a continuous production basis.

Largely as a result of research sponsored by the Lead Sheet and Pipe Manufacturers' Federation and carried out by the Association over a number of years, data on the mechanical properties of lead and the effects of extrusion conditions thereon have been accumulated. This body of knowledge now serves to indicate how to improve efficiency in the use of lead in domestic water-distribution pipes. Moreover, the Association is in a position to help the lead-pipe industry with advice on methods of controlling the properties of its products, so enabling it not only to increase its productivity but also to produce pipes of improved quality.

# HIGH-PRESSURE PLANT AT PORTOBELLO POWER STATION

## 2—TURBO-ALTERNATOR, FEED HEATERS AND OPERATING RESULTS

This article describes the 60-MW turbo-alternator recently installed in Portobello power station, and its associated feed-heating and other auxiliary equipment. Some account is also given of the operating results that have been obtained. The first of the two articles, published in last week's issue, described the boiler and associated equipment.

### STEAM TURBINE DESIGN

The turbo-generator, which was constructed by Messrs. Richardsons Westgarth (Hartlepool), Limited, Hartlepool, is designed for an output of 60 MW at the maximum continuous rating when supplied with steam at a pressure of 1,350 lb. per square inch and a temperature of 950 deg. F. at the stop valve, and with a vacuum of 29·1 in. of mercury. This choice of steam conditions was made to obtain the maximum efficiency with two-shift operation, a condition which made it desirable to avoid complications and high thermal stresses. Owing to the limited space it was decided to use a cross-compound unit, as shown in Figs. 12 and 13, on page 208, which are sections through the low-pressure cylinder and through the high-pressure and intermediate-pressure cylinders, respectively. As will be seen from Fig. 8, the machines, which are 48 ft. 6 in. long and 42 ft. 1 in. wide, are arranged with their axes across the turbine room.

In design, the turbine follows standard Brown Boveri practice. Ferritic materials are used in the high-pressure cylinder, an arrangement which, it is considered, permits a good thermal efficiency to be obtained without the high cost and disadvantages of reheating under the operating conditions that are likely to arise. One shaft carries both the high-pressure and intermediate-pressure rotors, which are arranged with opposed flow to balance the axial thrust. The high-pressure rotor is a solid ferritic forging of low-carbon vanadium steel and carries a 30-in. single-row impulse wheel the heat drop in which is considerably higher than in the 23 reaction stages which follow. One reason for adopting this construction was that it enabled the four inlet valves and their nozzle segments to be arranged symmetrically round the wheel, thus enabling better governing to be obtained under light-load conditions. The first stage blading, which is also ferritic, is welded to the rotor, precautions having been taken to avoid the development of both radial and circumferential cracks. The rest of the blading is dovetailed into the rotor body.

### STATOR BLADING

Some of the stator blading at the front end of the high-pressure cylinder (which is of low-creep mild steel) is easily removable so that a change-over can be quickly made to steam at 900 lb. per square inch and 900 deg. F. For this reason, the boiler has been designed to generate the necessary increased volume of steam. This form of insurance was adopted to ensure that the set would be available if teething troubles due to the high pressure and temperature occurred; it was found to be justified when weld cracks appeared in the impulse blading. These were subsequently eliminated by modifying the design. In addition, failure occurred in the reaction blading adjacent to the first stage, owing to fatigue. It was therefore necessary to replace it with heavier section blades and in some cases to use Jessops G-18-B steel for the purpose. This has apparently eliminated the difficulty. The glands are of the standard Brown Boveri design, consisting of narrow grooves cut in the shaft into which sealing strips of Monel metal or stainless steel are caulked with nickel wire.

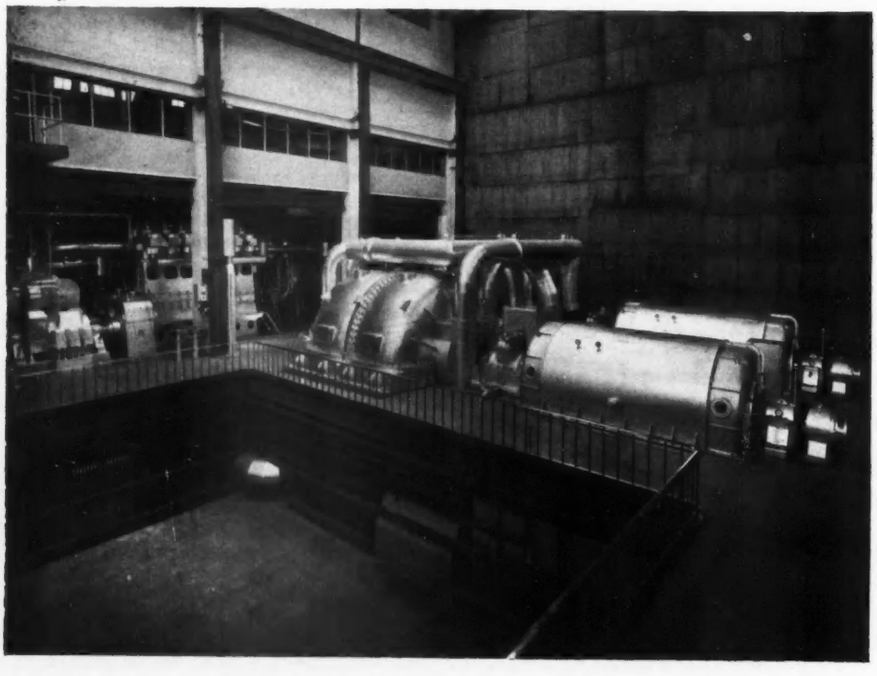


**Fig. 8 60-MW turbo-alternator with feed pump annexe on the left and main control room on the floor above. The interior of this control room was illustrated on page 179. The platform steel-work and other details in the foreground are normally covered with detachable aluminium plating.**

**Fig. 7 Turbine blading, showing silica deposited at dewpoint. This deposit caused a substantial reduction in efficiency during the summer months, but is now being mitigated by keeping down the silica content in the feed water.**

### INTERMEDIATE AND LOW-PRESSURE ROTORS

The intermediate-pressure rotor is of similar construction to the high-pressure rotor, except that it consists of a number of nickel-steel forgings, which are spigotted together and welded circumferentially against backing rings. The intermediate-pressure casing is also of mild steel and contains 23 reaction stages. The machine is designed so that the high-pressure and intermediate-pressure cylinders together produce about 50 per cent. of the output, the cross-over pressure necessary to obtain this result being about 115 lb. per square inch at a load of 60 MW.

The low-pressure section of the turbine consists of a single-flow cylinder with a double-flow portion made up of 13 reaction stages in each and a quadruple-flow portion with three reaction stages in each. These sections are designed to ensure balanced thrust under all conditions. The choice of quadruple flow for the last stages was due to the large exhaust volume which, in turn, was a consequence of the high vacuum of 29·1 in. The design of this cylinder is a modification of the standard Brown Boveri practice, four exhaust-blade annuli being arranged between two bearing centres and the middle bearing previously employed being discarded. The rotor is constructed of a number of nickel-steel forgings, which are spigotted together and welded against backing rings. As the steam flow in this cylinder is symmetrical there is no end-thrust to be considered and the design is such that steam is admitted to the ends of the rotor adjacent to the main bearings where the clearances are small. The outer casing of the machine now in operation is of cast iron, but in the two following units it will be fabricated from mild-steel sheet and bars and will consist of a " squirrel cage " which will carry the stator-blading rings.

### WATER SEPARATION PROBLEMS

Assuming a reasonably good turbine efficiency, the steam cycle chosen necessarily results in a high degree of water separation in the final rows of blading. In fact, the change-over to wet

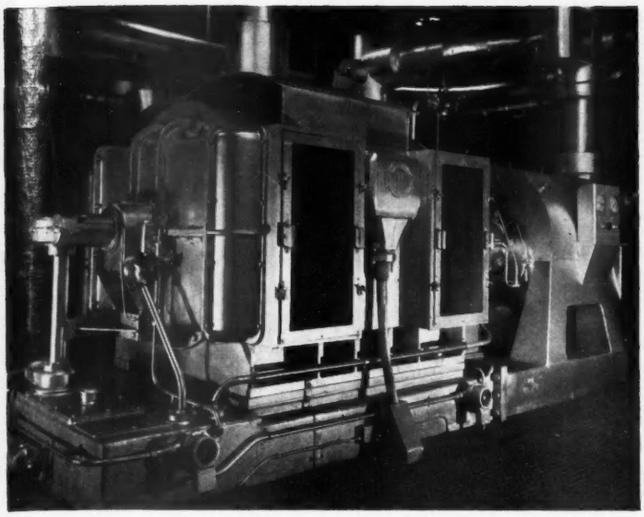


**Fig. 9 The centrifugal feed pump driven by a 2,050-h.p. 3·3-kV motor is shown on the left. It has an output of 600,000 lb. per hour against a head of 1,650 lb. per square inch. The Portobello feed-pump installation also includes the electrically-driven reciprocating pump (Fig. 10) which performs the same duty at a higher efficiency; and an emergency pump (Fig. 11), which is steam driven and started automatically by a water-level relay in the boiler.**

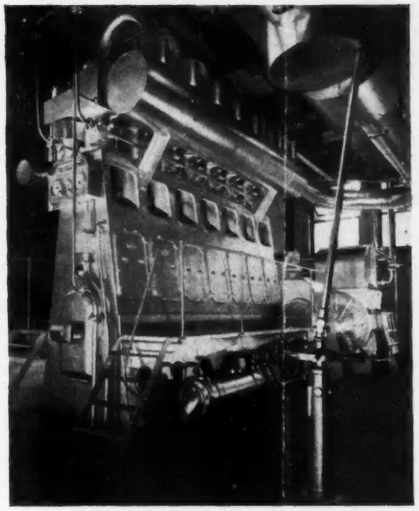


**Fig. 10 Reciprocating feed pump.**

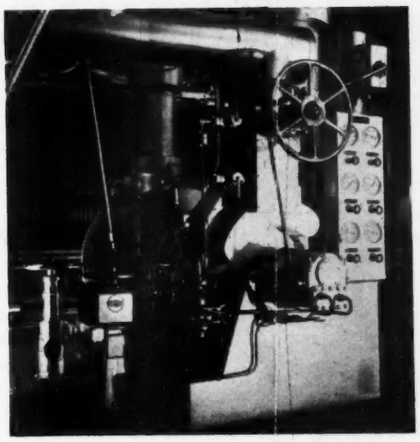


**Fig. 11 Emergency steam-driven pump.**

conditions actually occurs almost immediately the steam enters the low-pressure cylinder. A system of water drainage has therefore been developed by Richardsons, Westgarth and Brown Boveri, in which the stator casing opposite the blade tips is provided with an annular slot. This slot contains "diffuser" blades which are set at an appropriate angle and are of such an area that they will pass the amount of water that is likely to be separated out at each stage without wasting steam. As the output of each of the two alternators forming the set can be metered separately, it has been possible to make tests on the "wet" cylinder alone. In these tests the condition line (and thus the dew-point along the blading) was varied over a considerable range and it was found that with a constant inlet-steam pressure and an inlet-steam temperature varying from 870 deg. to 950 deg. F., the thermodynamic efficiency of the low-pressure blading, after an allowance had been made for the amount of steam drawn off for feed heating, remained approximately constant, even though there was a considerable difference in the total quantity of water to be removed. At the lower temperature the point of water separation moved nearer the high-pressure end, but this was dealt with quite efficiently by the drainage system. In making these tests, the quantity of steam passing through each section of the blading was computed.

It is not claimed that, as a result of these tests, the low-pressure blading of a turbine running wet is as efficient as if the steam were dry, but with adequate drainage it is clearly practicable, as Mr. J. F. Field points out, to operate satisfactorily under these conditions. With the standard Brown Boveri reaction blading the erosion of the leading edges of the moving blades increases with time up to a point where it ceases, or at least continues extremely slowly. The efficiency is therefore not affected to any measurable degree. This is probably due to the fact that with 50 per cent. reaction blading the velocities of both the steam and the blading itself at the point of entry are so low as to have virtually no effect on the efficiency. From this it may perhaps be deduced that the use of an extra high-pressure non-reheating cycle and a moderate inlet temperature is attractive, even though the efficiency of the exhaust end blading is slightly lower than it would be were reheating used. At any rate, it may be claimed that the complexity and expense of the reheating cycle has been avoided and, although the ideal heat cycle is in this respect inferior to the reheating cycle, assuming the same throttle temperature, British experience seems to show that the practical difference is small.

## CONDENSING AND FEED-HEATING

The low-pressure cylinder discharges into a single shell condenser of Richardsons Westgarth manufacture, which has a cooling surface of 50,500 sq. ft. and, as already mentioned, is designed to maintain a vacuum of 29·1 in., although 29·25 in. can be reached when the temperature is low. Cooling water for this purpose is drawn from the Firth of Forth through shafts and tunnels by a separate vertical-spindle circulating pump for each set, which were manufactured by Drysdale and Company Limited, Yoker, Glasgow, and are driven by 750/510-h.p. variable-speed alternating-current motors supplied by Laurence, Scott and Electromotors, Limited, Norwich. Each pump can deliver 30,000 gallons per minute. The water is returned to the sea through tunnels.

The condensate is discharged into a six-stage feed heating system which is supplied with steam from three extraction points on the intermediate-pressure turbine and a similar number on the low-pressure turbine. The lowest pressure extraction point is connected to a conventional surface heater, while the next higher feeds a combined heater and de-aerator, which is situated at a comparatively high level near the surge tanks. An Aiton triple-effect evaporator with an output of 25,000 lb. of water per hour is also installed. The other four heaters are on the discharge side of the feed pumps and are of Richardsons, Westgarth high-pressure type with hair-pin shaped cupro-nickel tubes.

The system includes a complete installation of three feed pumps. One is driven by a 2,050-h.p. 3·3-kV squirrel-cage motor of Bruce Peebles manufacture and has an output of 600,000 lb. per hour against a head of 1,650 lb. per square inch. This pump, of the centrifugal type and made by G. and J. Weir Limited, Glasgow, is shown in Fig. 9. There is also a reciprocating pump of the same make which is driven by a pair of variable-speed alternating-current motors and operates at a somewhat higher efficiency. Finally, there is a steam-driven pump, which was also manufactured by Messrs. G. and J. Weir, and is arranged to start automatically by the operation of a water-level relay in the boiler. It can be run up from cold to full load in about 30 seconds.

## ALTERNATOR DESIGN

The high-pressure and intermediate rotors of the turbine are directly connected to one 30-MW alternator and the low-pressure rotor to another, both sets being designed to generate three-phase current at a pressure of 13·2 kV and a power factor of 0·8. The stator windings of the two machines are coupled together and are solidly connected to the primary winding of a 75-MVA, 13·2/33-kV, transformer, which was manufactured by Messrs. Bruce Peebles and Company, Limited, Edinburgh. Compared with normal British practice the short-circuit ratio of these machines is relatively low, but they have proved entirely satisfactory in operation. Each alternator is also directly coupled to a main exciter and to a voltage regulator of Swiss manufacture. This enables the power factor and kilovolt-ampere loading to be maintained at the correct values under all operating conditions irrespective of the power load. Pilot excitation is provided from a rectifier-charged battery, the combination enabling both alternators to be sufficiently excited to pull themselves into step at about 400 r.p.m., when they are being started. Below this speed steam is by-passed into the low-pressure cylinder to synchronise it with the high-pressure cylinder, but is subsequently shut off and the main governor system brought into operation.

Mechanically, the alternators are of conventional type although the rotors consist of steel "cheeses," which are spigotted together and are held in position by a pin of high-tensile steel with screwed ends to which the stub shafts are attached. There is no welding of any sort.

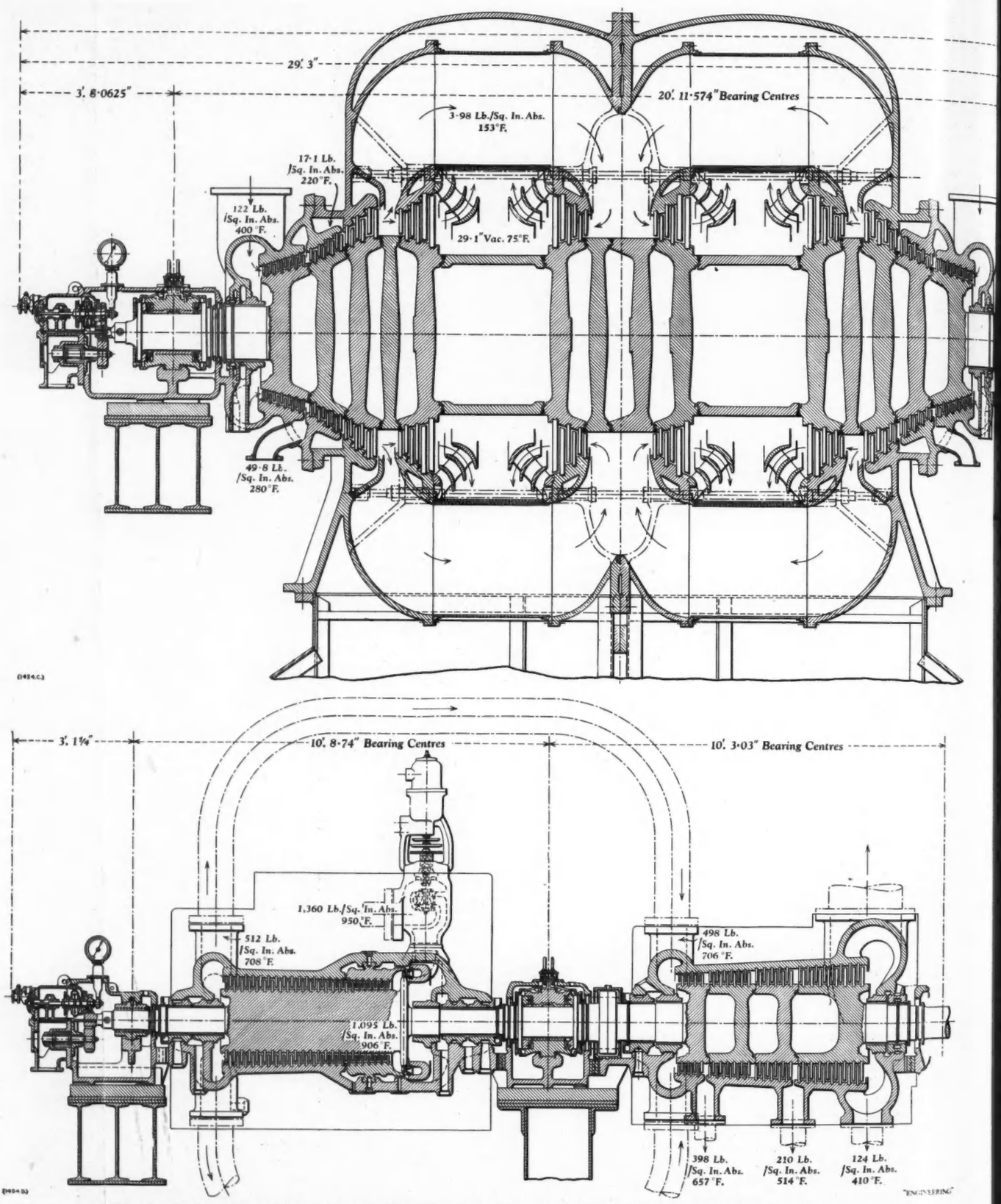



**Fig. 13 Section through high and intermediate-pressure cylinders of 60-MW, set showing governing arrangements.**

Ventilation is effected by a single cooler which is divided into two sections in series, one being cooled by the condensate and the other by sea water. This system has been adopted entirely for safety reasons.

## SWITCHGEAR

The 33-kV side of the main 75-MVA transformer is connected to a seven-panel switchboard, which was manufactured by Messrs. Ferguson Pailin, Limited, Manchester. This is equipped with a single 'bus-bar of the condenser bushing type mounted in air with metal shrouds. The circuit-breakers are of the vertical isolation type, with a rupturing capacity of 1,500 MVA, and are completely phase-segregated.

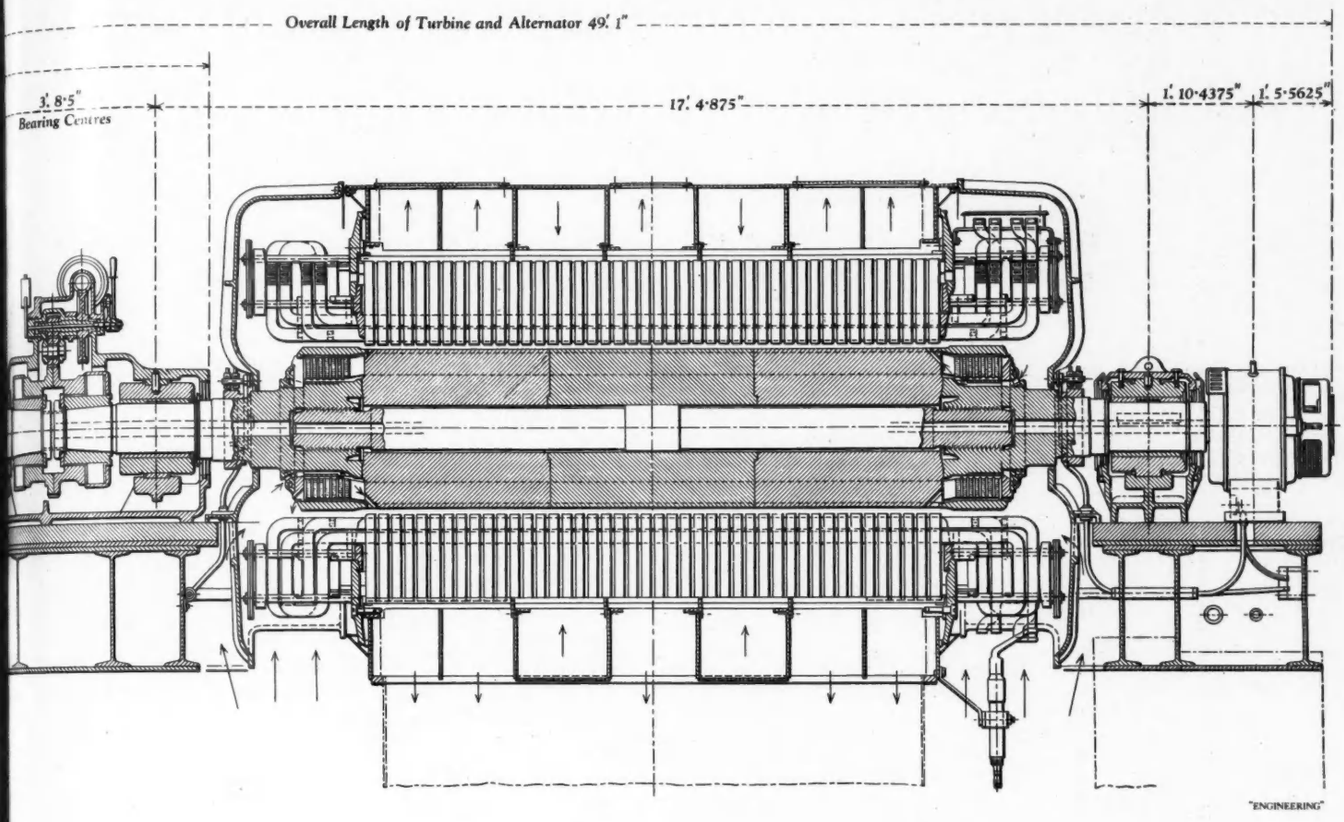



**Fig. 12 Section through low-pressure cylinder of 60 MW cross-compound unit, showing one of the 30-MW alternators. Cross-compounding was adopted owing to the limited space available.**

Two 132/33-kV grid transformers and two reactor units, through which a supply is given to the 750-MVA distribution switchgear, as well as a 'bus section unit, are also controlled from this board.

The 750-MVA distribution switchgear is mounted on two boards in separate houses and is supplied through the reactor units just mentioned. Each of these units is connected to two reactors through T-insulators, in such a way that the 1,500-MVA switchboard can be coupled to either or both of the distribution switchboards. By-pass isolators are also provided on the 1,500-MVA switchgear so that the generators can be directly connected to the reactor feeders in emergency. All the switches are remotely controlled from a panel in the power station by telephone-type relay equipment. In the case of the generators, the relays for this purpose are installed in the power station, while those for the remaining switchgear are in the basement of the switch house.

## EFFICIENCY OF 32 PER CENT.

A series of tests have recently been carried out on this plant, the results of which show that the performance of the steam turbine alone is within 1 per cent. of the guaranteed figure. A number of eight-hour tests, conducted with minor variations in the steam conditions, produced an average thermal efficiency from coal input to electricity sent out of about 32 per cent. after the power absorbed by the auxiliaries had been deducted and assuming the higher calorific value of the coal in making the calculation. Immediately after these tests, the electricity sent out in November, 1953, was 41·88 million kWh, the consumption of coal with a calorific value of 11,054 B.Th.U. per lb. being 18,023 tons, or 0·964 lb. per kilowatt-hour. The resulting thermal efficiency was therefore 32·03 per cent. This figure is believed to be superior to that achieved by any other plant running at the moment in Great Britain.

During the 12 months ended December 31, 1953, the electricity sent out amounted to 451·23 million kWh, 207,307 tons of coal and 220 tons of oil being consumed. This gives an average fuel consumption of 1·03 lb. of coal per kilowatt-hour sent out and an overall efficiency of 30·87 per cent. These figures are not so good as those for November alone, owing to considerable trouble earlier on with silica deposits on the blading of the low-pressure cylinder at the point where the steam changes from the dry to the wet condition. These deposits, the nature of which can be seen in Fig. 7, caused a deterioration in the turbine efficiency during the six summer months, as well as some reduction in output. The load factor during this 12-month period reached the extremely high figure of about 92 per cent., a result which was partly due to overloading the machine during the day time. Commercially, about £4,000 a week in fuel costs has been saved relative to the average cost of production on the grid as a whole. It is therefore clear that any lack of availability with such high efficiency sets is a serious commercial loss.

In dealing with the capital costs of this extension, it must be noted that the coal and ash-handling plant were extended so as to be capable of serving a 500-MW station. Assuming that the first of the 60-MW high-pressure sets is charged with one-sixth of the cost of this equipment, its cost alone has worked out at about £40 per kilowatt. The order for this set was, however, placed in 1946, since when prices have steadily increased. The estimated cost of the next two sets it is proposed to install are therefore likely to be higher. In fact, including the cost of alterations to the coal sidings, an installation of 180 MW will, it is believed, cost some £8·6 million or £48 per kilowatt. With the further remodelling of the station, which is now feasible, it should be possible, however, to reduce the cost per kilowatt considerably below this figure. As it is, the overall cost of the extension is probably the lowest of any plant of post-war construction, due to the use of a site where certain existing facilities could be re-utilised.

The reconstruction of Portobello was planned by Mr. J. F. Field when he was city electrical engineer and manager for the Edinburgh Corporation. He was assisted by Mr. P. d'E. Stowell, who was then deputy engineer, and manager of the department, and is now chief engineer of the Merseyside and North Wales Electricity Board. Messrs. Kinnear and Gordon acted as consulting engineers for the foundations, and Messrs. Andrews, Kent and Stone for the structural steel work, while Mr. R. G. Forgie, city architect of Edinburgh, was responsible for the architectural treatment. After the main design had been settled, Messrs. Kennedy and Donkin were appointed consulting engineers for the mechanical and electrical engineering work.

# COLLAPSE LOAD FACTOR FOR A RIGID FRAME STRUCTURE

## THEORY FOR BEAMS CARRYING DISTRIBUTED LOADS IN MULTI-STOREY MULTI-BAY FRAMES

*By M. R. Horne*, M.A., PH.D., A.M.I.C.E.

Various methods of calculating the plastic collapse loads of rigid frame structures have been published, several being listed at the end of this article. The examples used to illustrate these methods are, as a rule, restricted to solutions of simple frames of the types shown in Figs. 1, (*a*) and (*b*), below, the loads being concentrated at a few points only.[1, 2, 3] In such cases there are only a few positions in which plastic hinges can occur, and not all of the methods can conveniently be extended to frames carrying distributed loads. A graphical method of analysis which will deal with simple frames carrying distributed loads, as shown in Figs. 2, (*a*) and (*b*), is available,[3, 4] but the same method becomes unmanageable for more extensive structures.

Two practicable methods of obtaining the collapse loads of frames of the type shown in Fig. 3 have recently been presented. In one method, devised by Neal and Symonds,[5] elementary collapse mechanisms are combined to obtain the correct mechanism, the equation of equilibrium being solved by the use of virtual work equations. In the second method,[6] the bending moments in the structure are progressively modified by a moment-distribution process until they just represent a state of plastic collapse. The same simplifying assumption has to be made in each of these methods in order to avoid undue complication, namely that whenever a plastic hinge occurs between the ends of a beam, it will occur at the centre, as shown in Fig. 4 (*a*). (In the diagrams of collapse mechanisms in this paper, hinges actually occurring at a joint are shown by black dots, while hinges within the lengths of members are indicated by open dots.) Having obtained the load factor at collapse on the basis of such a simplification, modifications may be made allowing for the general occurrence of the sagging bending-moment hinges away from the centres of the beams, as indicated in Fig. 4 (*b*). These modifications are readily made – with sufficient accuracy for practical purposes – by considering each beam in turn.[5, 6] It is possible however to obtain a single general expression which will give the correct load factor directly, provided the correct mode of collapse, apart from the exact positions of the sagging moment hinges, is known. The purpose of this paper is to give the derivation of such an expression, and to illustrate its use by reference to a numerical example.

The work described in this article was carried out at the Engineering Laboratory, Cambridge University, under the direction of Professor J. F. Baker, Head of the Department of Engineering. It forms part of a general investigation into the behaviour of steel structures in the plastic range being carried out at Cambridge with the assistance of the British Welding Research Association and the Department of Scientific and Industrial Research.

### GENERAL EXPRESSION FOR COLLAPSE LOAD FACTOR

The rigid frame structure shown in Fig. 3 may collapse either in a side-sway mechanism of the type shown in Fig. 4 (*b*), or by the local failure of a beam without side-sway, as illustrated by beams A B and E F in Fig. 5. The determination of the load factor at collapse in the latter case presents no difficulties, and will not be considered here.

The load factor at collapse when failure is accompanied by side-sway may be obtained by writing down the virtual-work equation for the structure under load, the assumed displacements corresponding to the collapse mechanism. Since the contributions of the beam loads and bending moments to this equation are affected by the exact positions of the sagging moment hinges, it is necessary to consider these contributions in detail. For this purpose, reference is made to the beam *a c b*, shown in Fig. 6, of length *l*, having a full plastic moment M and carrying a uniformly distributed working load of W. The structure of which the beam is a component collapses with side-sway towards the right (direction *a b*) at a load factor of $\lambda$. At collapse, a plastic hinge under sagging moment develops in the beam at *c* at a distance *x* from end *a*, at which no hinge occurs; this beam is characteristic of beams A B, E F, G H and H I in Fig. 4 (*b*). It will be observed therefore that the end *a* of the beam (remote from the end towards which side-sway deflection occurs) is in rigid continuity at collapse with at least one stanchion length; thus in Fig. 4 (*b*), beam A B is in continuity at A with stanchion A D, while beam E F is in continuity at E with both the stanchion lengths E B and E H. Regarding the occurrence of a hinge at the end *b* (towards which side-sway deflection takes place), two cases arise. Beams in which such a hinge does occur, for example,

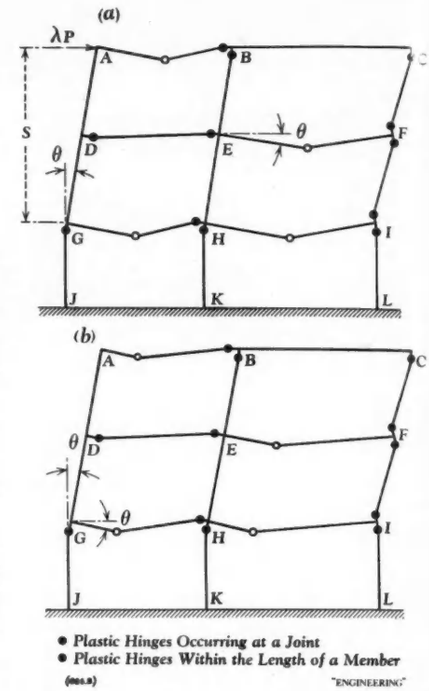



**Fig. 4 (*a*) Shows how the frame collapses if hinges are formed at mid-span of the beams while (*b*) shows the actual mode of collapse.**

beams A B and G H in Fig. 4 (*b*), will be referred to as of Type 1, while beams not containing a hinge at this end will be spoken of as of Type 2, for example, beams E F and H I in Fig. 4 (*b*).

The contributions of beams of Type 1 to the internal energy in the virtual-work equation may be obtained from a study of Figs. 7, (*a*) and (*b*). The left-hand side *a c* of the beam rotates through an angle $\theta$ in common with the adjacent stanchion with which it is in rigid continuity, as at the joint G shown in Fig. 4 (*b*). Hence the remainder of the beam *c b*, as shown in Fig. 7, rotates through an angle $\left(\frac{x}{l-x}\right)\theta$ in the opposite direction. In Fig. 7 (*a*), the joint at end *b* does not rotate, this being the case for beam A B in Fig. 4 (*b*). In Fig. 7 (*b*), this joint rotates through an angle $\theta$, as for beam G H in Fig. 4 (*b*). The internal work is given for either Fig. 7 (*a*) or Fig. 7 (*b*) by the quantity $U_1\,\theta$, where

$$U_1\,\theta = \left(\frac{l}{l-x}\right)M\,\theta + \left(\frac{x}{l-x}\right)M\,\theta + \delta\,(M\,\theta),$$

that is,

$$U_1 = \left(\frac{l+x}{l-x}\right)M + \delta\,(M) \quad . \; . \quad (1)$$

In the last term, $\delta$ is a multiplier which is zero for the beam in Fig. 7 (*a*) and unity for the beam in Fig. 7 (*b*); $\delta$ will be used to denote a factor which can only take the values of either unity or zero. When two or more $\delta$'s appear in the same equation or expression, they are to be regarded as independent and not necessarily of the same value.

Beams of Type 2 are connected at end *b* to a joint which rotates through an angle of $\left(\frac{x}{l-x}\right)\theta$ in common with the length *c b*, as shown in Fig. 8. For this reason, all the remaining members meeting at the joint must contain plastic hinges, as illustrated by the joints F and I in Fig. 4 (*b*). The members $b\,d_1$, $b\,d_2$ and $b\,d_3$ of Fig. 8 have full plastic moments $M_1'$, $M_2'$ and $M_3'$, respectively, and rotate through clockwise angles $\delta\,(\theta)$ where $\delta$ is zero

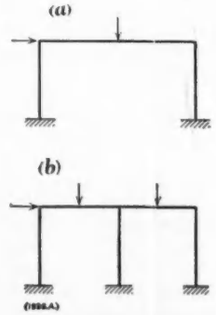



**Fig. 1 Simple frames with concentrated loads.**

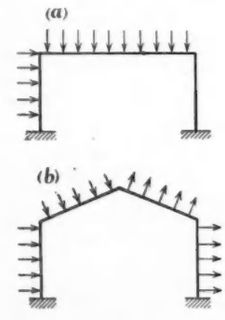



**Fig. 2 Simple frames with distributed loads.**

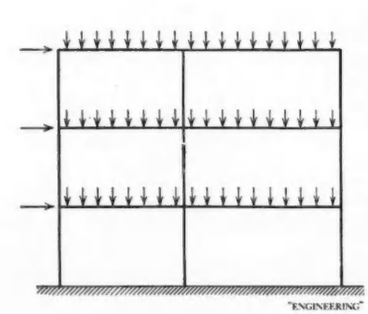



**Fig. 3 Multi-storey, multi-bay frames with distributed loads.**

or unity (it is readily seen that $\delta$ is zero for $b\,d_2$ since clockwise rotation would imply independent failure of this beam). At joint I in Fig. 4 (*b*), $\delta$ is unity for the stanchion length I F and zero for I L. If the internal work connected with this beam is $U_2\,\theta$, it follows that

$$U_2\,\theta \left( = \frac{l}{l-x}\right) M\,\theta + \left(\frac{x}{l-x}\right)(M_1' + M_2' + M_3')\,\theta + \delta(M_1'\,\theta) + \delta(M_2'\,\theta) + \delta(M_3'\,\theta).$$

Let

$$M_1' + M_2' + M_3' = M',$$

and

$$\delta(M_1') + \delta(M_2') + \delta(M_3') = M'',$$

then

$$U_2 = \left(\frac{l}{l-x}\right) M + \left(\frac{x}{l-x}\right) M' + M''. \quad (2)$$

It should be noted that M′ is the total clockwise moment acting on the end *b* of the beam *a b* in Fig. 8, and hence this type of beam failure can only occur when $M' < M$.

In addition to the sum of the terms $U_1\,\theta$ and $U_2\,\theta$, the internal work in the virtual-work equation includes the contribution of hinges at which the relative rotations are unaffected by the exact positions of the sagging moment hinges in the beams of Types 1 and 2. Such plastic hinges occur in Fig. 4 (*b*) at D and E in beam D E and at G in stanchion G J. The total internal work contributed in this way will be denoted by $U_0\,\theta$.

In beams of both Types 1 and 2, the external work contributed to the virtual-work equation by the factored beam load $\lambda W$ is given by $\frac{1}{2}\lambda W x\,\theta$, since the mean vertical descent of the load is $\frac{1}{2}x\,\theta$. The contribution of a typical horizontal load $\lambda P$ to the external work (see Fig. 4 (*a*)) is given by $\lambda P S\,\theta$, where S is the total stanchion length rotating through an angle $\theta$ below the point of application of the load.

The complete virtual-work equation may now be written down, and becomes, after the cancellation of $\theta$,

$$\lambda[\Sigma P S + \tfrac{1}{2}\Sigma W x] = U_0 + \Sigma_1\left[\left(\frac{l+x}{l-x}\right) M + \delta(M)\right] + \Sigma_2\left[\left(\frac{l}{l-x}\right) M + \left(\frac{x}{l-x}\right) M' + M''\right]. \quad . \quad . \quad . \quad (3)$$

The first summation on the right-hand side extends over all beams of Type 1, while the second extends over all those of Type 2.

Each set of values of the variables $x$ defines a mechanism of collapse, and the correct mechanism will be that for which the load factor $\lambda$ is a minimum.[5, 6, 7] Hence $\frac{\partial \lambda}{\partial x} = 0$ for all beams of Types 1 and 2. In the case of beams of Type 2, it is found from equation (3) that

$$x = l - \sqrt{\frac{2(M + M')\,l}{\lambda W}}, \quad . \quad . \quad . \quad (4)$$

while for beams of Type 1, the same equation applies if M′ is replaced by M. The substitution of these values of $x$ in equation (3) gives the following quadratic equation for $\sqrt{\lambda}$.

$$\lambda[\Sigma P S + \tfrac{1}{2}\Sigma W l] - \sqrt{\lambda}\,\Sigma\sqrt{2(M + M')\,W l} + \Sigma M' - \Sigma_1\,\delta(M) - \Sigma_2(M'') - U_0 = 0. \quad . \quad . \quad . \quad (5)$$

The summations $\Sigma$ extend over beams of both Types 1 and 2 (M′ replaced by M for Type 1 beams), the summation $\Sigma_1$ over beams of Type 1 only, and $\Sigma_2$ over beams of Type 2 only.

The calculation of $\lambda$ may be somewhat simplified by introducing the load factor $\lambda_c$, which corresponds to $x = \frac{l}{2}$ in all beams of Type 1 and 2, for example, as in Fig. 4 (*a*) for the frame illustrated in Fig. 3. This will usually have been calculated before attempting the complete solution; it may be obtained from the general virtual-work equation (3) by substituting $x = \frac{l}{2}$. It is convenient to express the external work for this case, in which every sagging moment hinge within the length of any beam is at mid-span, by $U_c\,\theta$, so that

$$\lambda_c U_c = \Sigma(2M + M') + \Sigma_1\,\delta(M) + \Sigma_2(M'') + U_0, \quad . \quad . \quad (6)$$

where,

$$U_c = \Sigma P S + \tfrac{1}{4}\Sigma W l. \quad . \quad (7)$$

The elimination of $U_0$ between equations (5) and (6) leads to

$$\lambda[U_c + \tfrac{1}{4}\Sigma W l] - \sqrt{\lambda}\,\Sigma\sqrt{2(M + M')\,W l} - [\lambda_c U_c - \Sigma 2(M + M')] = 0. \quad . \quad (8)$$

Equation (8) is more convenient than equation (5) since it does not contain the partial summations $\Sigma_1$ and $\Sigma_2$ and the quantity $U_0$. It will give the correct value of the collapse load provided the terms under the summation signs include all those beams containing a sagging hinge within their length, and exclude all other beams. Whether this condition has been satisfied can only be checked by computing the bending moments throughout the structure for the load factor derived from equation (8). This is most conveniently carried out by the application of plastic moment distribution.[6] If the full plastic moment is anywhere exceeded, a modification must be made in the assumed collapse mode and the load factor at collapse recalculated.

The exact value of $\lambda$ can only be obtained by solving a quadratic equation, but a very close estimate may be made in one operation without this necessity.

Eliminating $U_0$ between equations (5) and (6),

$$[\lambda_c - \lambda]\,[\Sigma P S + \tfrac{1}{4}\Sigma W l] = \tfrac{1}{4}\Sigma W l - \sqrt{\lambda}\,\Sigma\sqrt{2(M + M')\,W l} + \Sigma_2(M + M'). \quad . \quad . \quad (9)$$

Now $\lambda_c$ will not differ greatly from $\lambda$, and hence $[\lambda_c - \lambda]$ may be computed with sufficient accu-

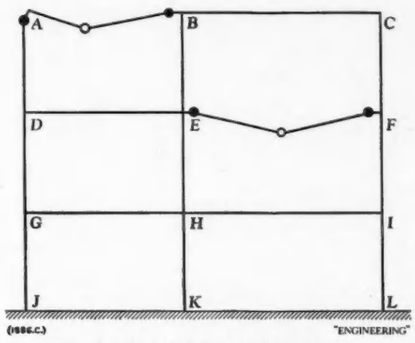



Fig. 5. Local failure of beams.

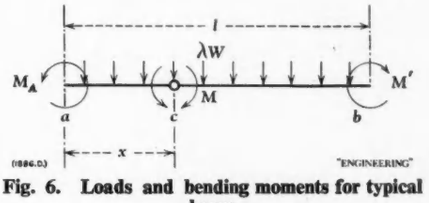



Fig. 6. Loads and bending moments for typical beam.

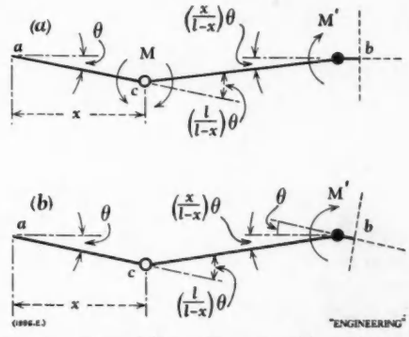



Fig. 7. Beam failure—Type 1, with a hinge at the beam-stanchion connection.

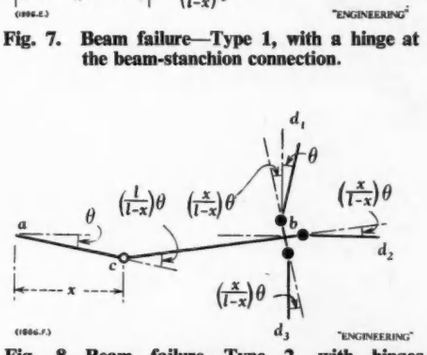



Fig. 8 Beam failure—Type 2, with hinges developing in the stanchion and the adjacent beam.

TABLE I.—Accurate Estimation of $\lambda$.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Beam | Length $l$ | Load W | Full Plastic Moment, M | End Moment of Resistance, M′ | W $l$ | (M + M′) | $\sqrt{(M + M')\,W l}$ | $x$ (Equation 4) | $x$ (after Neal) |
| A B | 2 | 2 | 1·0 | 1·0 | 4 | 2·0 | 2·828 | 0·554 | 0·54 |
| D E | 2 | 4 | 1·5 | 1·5 | 8 | 3·0 | 4·899 | 0·748 | 0·75 |
| E F | 2 | 5 | 1·5 | 1·5 | 10 | 3·0 | 5·477 | 0·880 | 0·89 |
| G H | 2 | 6 | 2·0 | 2·0 | 12 | 4·0 | 6·928 | 0·819 | 0·83 |
| H I | 2 | 8 | 2·0 | 2·0 | 16 | 4·0 | 8·000 | 0·977 | 0·98 |
| SUM | | | | | 50 | 16·0 | 28·132 | | |

TABLE II.—Approximate Estimation of $\lambda$.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Beam | Length, $l$ | Load, W | Full Plastic Moment, M | End Moment of Resistance, M′ | (M + M′) | $\frac{W l\,\lambda_c}{8(M + M')}$ | $\sqrt{\text{Col. (7)}}$ | $\{1 - \text{Col. (8)}\}^2$ | $\{\text{Col (6)} \times \text{Col. (9)}\}$ |
| A B | 2 | 2 | 1·0 | 1·0 | 2·0 | 0·4884 | 0·6988 | 0·0907 | 0·1814 |
| D E | 2 | 4 | 1·5 | 1·5 | 3·0 | 0·6512 | 0·8070 | 0·0373 | 0·1119 |
| E F | 2 | 5 | 1·5 | 1·5 | 3·0 | 0·8140 | 0·9022 | 0·0096 | 0·0288 |
| G H | 2 | 6 | 2·0 | 2·0 | 4·0 | 0·7326 | 0·8559 | 0·0208 | 0·0832 |
| H I | 2 | 8 | 2·0 | 2·0 | 4·0 | 0·9768 | 0·9883 | 0·0001 | 0·0004 |
| SUM | | | | | | | | | 0·4057 |

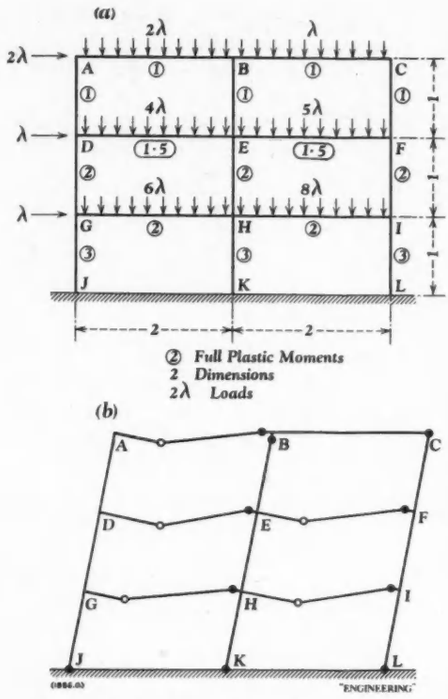



**Fig. 9 (*a*) Loads and proportions of the frame analysed in the article, and (*b*) the actual location of the hinges bringing about failure.**

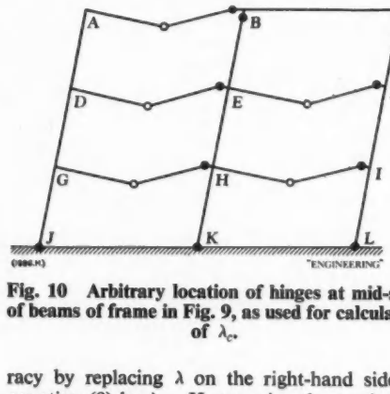



**Fig. 10 Arbitrary location of hinges at mid-span of beams of frame in Fig. 9, as used for calculation of $\lambda_c$.**

racy by replacing $\lambda$ on the right-hand side of equation (9) by $\lambda_c$. Hence using the symbol $U_c$ as already defined in equation (7),

$$\lambda = \lambda_c - \frac{2}{U_c} \Sigma \left[ (M + M') \left( 1 - \sqrt{\frac{\lambda_c W l}{8 (M + M')}} \right)^2 \right]. \quad . \quad . \quad . \quad (10)$$

The use of equations (8) and (10) in deriving the collapse load factor for a rigid frame carrying distributed beam loads will be illustrated by a numerical example. The three-storey, two-bay frame discussed by Neal[3] has been chosen.

## EXAMPLE

The loads and proportions of the frame are shown in Fig. 9 (*a*). Thus the beam D E is of length 2 units, has a full plastic moment of 1·5 units and carries a uniformly distributed load of 4 units. The problem is to determine the load factor $\lambda$ at which collapse will occur.

The general positions of the hinges in the structure at collapse are shown in Fig. 9 (*b*). The value of $\lambda_c$ is calculated from the virtual-work equation obtained when hinges are assumed at the centres of beams A B, D E, E F, G H and H I as in Fig. 10. It is thus found that

$$U_c = 21 \cdot 5$$

$$\lambda_c = 42 \div 21 \cdot 5 = 1 \cdot 954.$$

The calculation of the remaining terms in equation (8) is best carried out in tabular form, as shown in Table I. It is thus found that

$$\Sigma W l = 50 \; ; \; \Sigma (M + M') = 16 \; ;$$

and,

$$\Sigma \sqrt{(M + M') W l} = 28 \cdot 13.$$

Equation (8) thus becomes

$$\lambda (21 \cdot 5 + \tfrac{1}{4} \times 50) - \sqrt{\lambda} (\sqrt{2} \times 28 \cdot 13) - (42 - 2 \times 16) = 0,$$

whence

$$\lambda = 1 \cdot 912.$$

The values of $x$ giving the distances of the sagging moment hinges from the left-hand end of each beam may now be calculated from equation (4), and are given in column (9) of Table I. The values given by Neal (who obtained them by an approximate step-by-step procedure) are shown for comparison in column (10). The load factor of 1·912 is identical with that obtained by Neal, within the three significant figures quoted by the latter.

The value of $\lambda$ as given by the approximate equation (10) is derived from the calculations arranged in Table II and is thus found to be

$$\lambda = 1 \cdot 954 - \frac{2}{21 \cdot 5} \times 0 \cdot 4057,$$

$$= 1 \cdot 916.$$

This differs by only 0·2 per cent. from the accurate value, and is certainly sufficiently close for all practical purposes. Equation (10) may therefore be used in place of equation (8) if preferred. Its use has two advantages: first, it does not involve the solution of a quadratic equation; secondly, the result is given as a modification of the load factor $\lambda_c$ obtained by assuming sagging moment hinges at the centres of the beams and, as the value of $\lambda_c$ is relatively easy to calculate, the danger of a large error in the final result is very much reduced. The arithmetical labour involved in using equation (10) is approximately the same as that involved in the use of equation (8).

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# RESEARCH WORK OF THE UNITED STEEL COMPANIES*

*By F. H. Saniter*, B.ENG.

Many branches of science and technology are involved in the work of the Research and Development Department of the United Steel Companies, Limited, as it now stands, and it is our ability to draw suitably-composed teams from within our own organisation which had led us into the field of plant-scale experimentation—a field which has been inadequately cultivated in the past.

I think we first got the feel of this kind of thing from the Templeborough open-hearth furnace trials, which are fully recorded in Iron and Steel Institute Report No. 37 (1946). One result of these trials was the "K" furnace at Templeborough, one of the first single-uptake oil-fired furnaces to be tried in this country, a special feature being the sloping end wall designed to give a flow pattern beneficial to the life of the refractories. This design has proved admirable and since it has started rather in advance of where our more conventional furnaces left off, we feel that by observation of its service performance and suitable modification from time to time, there are good prospects of further improvement.

The open-hearth furnace has also been the object of practical work on the development of improved refractories and a most stimulating competitive situation has been created by the introduction of "all-basic" construction on the one hand and the judicious use of Silcrete, an improved silica refractory, on the other. It is interesting to record that since 1948 when the first "all-basic" furnace was put into commission at Templeborough the average life of a silica roof has increased from 125 casts, at a rate of 13 casts a week, to 200 casts, at a rate of 14 casts a week, thus appreciably raising the standard against which the performance of the all-basic furnace must be judged. There are now two all-basic furnaces in the shop and their output and refractory cost, are being watched.

Turning now to another branch of the company, Samuel Fox; attention has been paid to the development of an idea, which emanated from the manager of the electric-steel plant, whereby the charge of an electric-arc furnace would be pre-heated or pre-melted under an oil-fired hood after being placed in the body of the furnace, the body being transferred in due course to its normal position under the electrodes for completion of the heat. By this means, it was suggested, not only would the cost of electricity and electrodes per ton of steel be reduced to one-third, but also it would mean that if oil pre-melting were established as a regular practice the electrical equipment normally provided for a 10-ton cold-melt furnace would be capable of refining a 30-ton charge.

When the pre-melter idea was presented to the Research and Development Department, it aroused considerable interest and enthusiasm. First, the shape of the combustion space had to be considered and the expected flow pattern arising from various arrangements of burners and exit flues, determined. The next stage was to built a one-fifth scale hot model to determine whether ferrous metal could, in fact, be brought to melting temperature. This led to special consideration of burners, and with some initial help from Joseph Lucas, Limited, a burner, based on the principles of the jet-engine combustion chamber, was evolved which gave a very high heat release.

* Abstract from Presidential Address to the Sheffield Metallurgical Association, delivered on January 26, 1954.

From this, thanks to the courage of the Fox management, we jumped to full-scale operation and designed a pre-melting hood which has now been installed in the electric steel plant at Stocksbridge in conjunction with a 10-ton arc furnace. This unit embodies six of the special burners, which we call "jet-cans," each capable of burning 40 gallons of oil an hour, preheated air being supplied from a recuperator installed in the waste-gas system. Oil can be burnt under stoichiometric conditions to provide 82,000 B.Th.U.'s per hour per cubic foot of furnace volume – eight times the equivalent rate of heat release in an average open-hearth furnace. The equipment is shown in the drawing below.

As the trials of this pilot plant, which are designed to determine both the practicability and the economics of the process, are still in progress, I do not propose to quote results beyond saying that oil has been burnt for prolonged periods at a rate of 200/240 galls. an hour and the practicability of melting by this method has been established. Whether the economics of the operation prove to be attractive or not remains to be seen, but in any event a piece of valuable team work, involving both Fox and Research and Development Department personnel, has been accomplished and a great deal of valuable information and experience gained which is already being applied in other directions.

## CONTINUOUS CASTING

Another plant-scale operation for which we have a technical responsibility is the Rossi continuous casting machine which has been installed experimentally at the Barrow steelworks. The plant is illustrated on the right. The background of this is the desire to produce 80,000 to 100,000 tons of billets per annum from the existing open-hearth furnaces without recourse to the billet mill which is not only obsolete but quite uneconomic to operate on the basis of such a small annual tonnage. These billets are required to feed the existing re-rolling mills, the major part of the demand being for material of 2-in. square section.

It will be appreciated that the casting of billets as small as 2 in. square on a production basis is novel, to say the least, and presents unusual difficulty owing to the high speed of withdrawal necessary to achieve a reasonable production rate, not to mention the maintenance of the metal at a sufficiently high temperature for the duration of the operation. Indeed, the second of these problems was the first which had to be tackled and it was solved largely by the use of the jet-cans, to which I referred earlier, for preheating the ladle and maintaining the temperature of the metal during casting. It is now possible to tap at the normal temperature which would be employed in open-hearth practice and to maintain a sufficiently high temperature in the ladle until casting is complete.

The target set for the rate of casting is 5 tons an hour which is equivalent to about 200 in. a minute. This in itself set a problem since the $\frac{7}{16}$-in. diameter nozzle which gives such a rate of pouring is very prone to freeze up if the tundish and nozzle are not adequately insulated and preheated before casting starts. Casting into a 2-in. square mould also necessitates a clean stream of metal and the design of a suitable nozzle to achieve this required a good deal of thought and experiment. In the illustration below, the operator is seen controlling the stream of metal entering the mould.

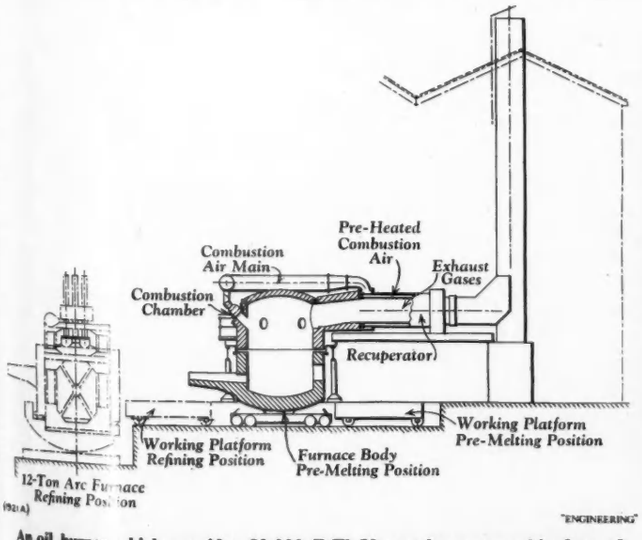
The development of this technique to the point at which a 5-ton ladle of metal can be cast into 2-in. square section material, in an hour, with absolute regularity has yet to be reached, but good progress has been made towards this objective and, on numerous occasions, we have achieved this rate of casting, a feat which many would have thought quite impossible a year ago. There are still many things to work out, not the least of which is how to dispose of a 50-ton open-hearth cast in a reasonable period of time. Another problem to be solved is that of finding a method of indicating the level of the metal in the mould and then linking this to the automatic control of the withdrawal mechanism.

## INCREASING SINTER OUTPUT

The final example to which I shall refer relates to an extensive investigation into the factors controlling the rate of sinter production on the four Dwight-Lloyd sinter strands at the Appleby-Frodingham works. These four strands had a nominal design capacity of 24,000 tons of sinter a week but, in view of the nature of the Appleby-Frodingham ore and the need to return a substantial proportion of the sinter fines to the feed, they had been de-rated to 18,000 tons a week. At the time the investigation was undertaken, output was running at considerably less than this figure and something had to be done about it. An added impetus was derived from the fact that a further four sinter machines were about to be ordered and it was highly desirable that our knowledge of the process, particularly in relation to Appleby-Frodingham ore, should be improved so that the findings could be taken into account in the design of the new plant.

The most immediate benefit was that it enabled the plant operators to control the mix (and hence the permeability of the bed) in such a manner that an output of 25,000 tons of sinter per week was quickly achieved. This figure has since risen to 30,000 tons a week. No less important was the provision of basic data from which the optimum relationship between bed depth, strand length and fan horse power for any given set of conditions could be calculated. This was promptly applied to the design of the four new strands which will be much better balanced units than the existing ones. They will come into commission shortly, almost exactly three years from the commencement of the trials.

**The continuous casting of billets directly from molten steel is being developed with this pilot plant.**




**An oil burner which provides 82,000 B.Th.U. per hour per cubic foot of furnace volume, and was evolved from the design of a jet-engine combustion chamber, is used in this hood for pre-melting arc-furnace charges.**

**Molten steel leaving the nozzle of the continuous casting plant shown in the top picture. The form and heat insulation of the nozzle are critical if continuous pouring is to be successful.**

# AERO-ENGINE COMPRESSOR AND TURBINE TEST HOUSE

## POWER SUPPLIED BY 10,000-H.P. STEAM TURBINES

For research and development work on the aerodynamic characteristics of full-scale aircraft-engine compressors and turbines, Armstrong Siddeley Motors Limited, Coventry, have installed a test house at their Ansty works, near Coventry. The plant, which has now been in operation for about two years, includes a pressure-tight cell for testing compressors under reduced pressures, a test-rig fitted with two Heenan-Dynamatic 2,000 horse-power eddy-current dynamometers for testing gas turbines, a central control room, and automatic photographic recording equipment for recording the various manometer readings.

The acoustic treatment of the test house is by Horace W. Cullum and Company, Limited, Flowers-mews, London, N.19.

Power for driving the test-rigs is supplied by a 10,000 h.p. marine steam-turbine set of the type fitted in Hunt-class destroyers. In selecting 10,000 h.p. for the steam-turbine set, the range of engine sizes likely to be made in the future and the powers necessary to drive their components were estimated. The extent of the power reduction for testing these future components is limited by the necessity for running them at a Reynolds number above the critical value.

### COMPRESSOR TESTING

The pressure at the compressor inlet may be progressively reduced to simulate conditions at increasing altitude, the power absorbed by the compressor then decreasing with inlet density. It is thus possible to carry out tests of compressors which absorb far more than 10,000 h.p. at sea level by choosing a suitable altitude at which to run the test. The arrangement shown in Fig. 1 is used.

The air supply to the compressor test cell enters a nozzle chamber, on the roof of the test house, through a Vokes filter. The air then passes through an electrically-operated throttle valve in a 48-in. diameter pipeline which is connected to the test cell. The compressor inlet pressure can be adjusted by this valve at the beginning of the test, this setting then being held constant throughout the test. A baffle at the duct exit dispenses the air evenly through the cell.

The compressor outlet is connected to a 36-in. diameter pipeline which is taken up to the roof. An electrically-operated outlet throttle valve in this duct controls the back pressure on the compressor. After passing through this valve, the air is led to a Cullum detuner and thence to atmosphere, which effectively reduces the noise from the exhaust to an acceptable level. During the test the outlet throttle valve is progressively closed to vary the pressure ratio and the mass flow. Recordings are made of the total and static pressure and temperature at the compressor inlet and outlet and in addition pressure and temperature measurements can be made at any required positions in the internal flow path through the compressor. The speed of the compressor is varied as required by regulating the steam flow to the marine turbines.

### PRESSURE-TIGHT TEST CELL

The compressor test cell itself, illustrated in Fig. 3, is a 10-ft. diameter steel cylindrical chamber. The main structure for mounting the compressor test bed inside the cell comprises two longitudinal channel-section beams carrying a series of secondary transverse beams. The main channels transfer their loads directly to six fabricated steel feet (three on each side) welded to the outside of the cell. These support the cell and are bolted to a grillage of I-section joists embedded in the concrete floor of the building. The grillage is extended into the adjacent engine room to form a base on which the speed-increasing gear-box is mounted.

The forward circular end-plate of the cell forms a removable door for installing the compressor for test, a travelling hoist being provided on the cell roof for this purpose. In the side-walls of the cell, a series of openings are provided to allow for varying the position of the outlet pipe connection, to accommodate different types of compressor. All the pressure-measuring pipe lines, and the electrical leads for the thermometers and thermocouples, are connected to a " battery plate " on the side of the cell, to which are also connected the external pipelines and wiring leading to the manometers and instruments in the camera and control rooms.

The drive transmission unit is mounted externally on the rear face of the compressor cell. It comprises a cast-iron housing which extends into the cell, the overhung end being additionally

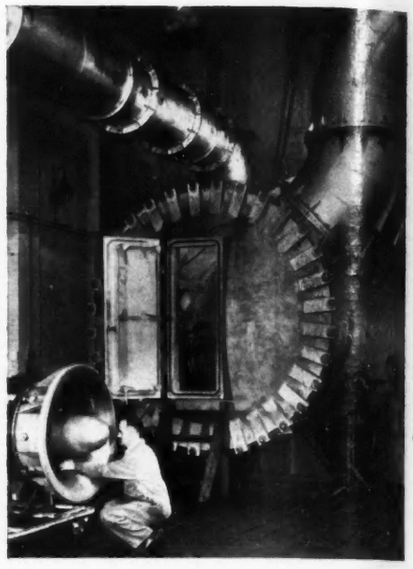


Fig. 3 Compressor test cell, in which the compressor is operated at reduced pressure to minimise the power required.

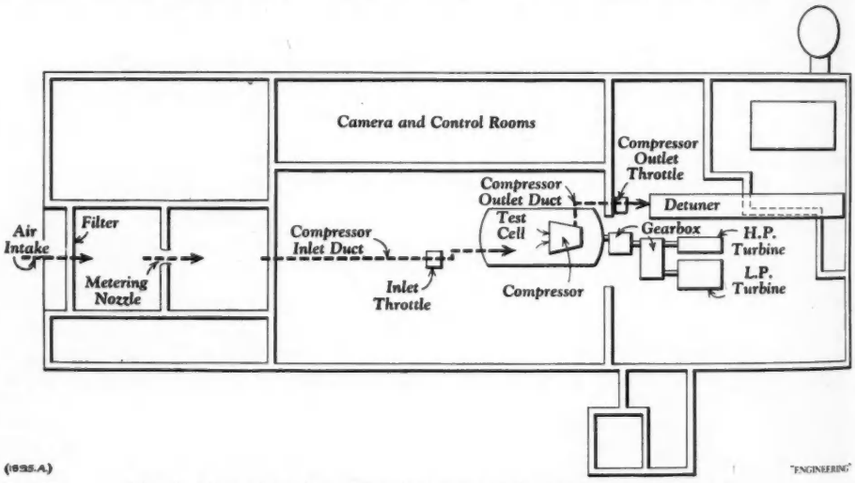



Fig. 1 Plan of test-house showing layout of ducting for compressor test.

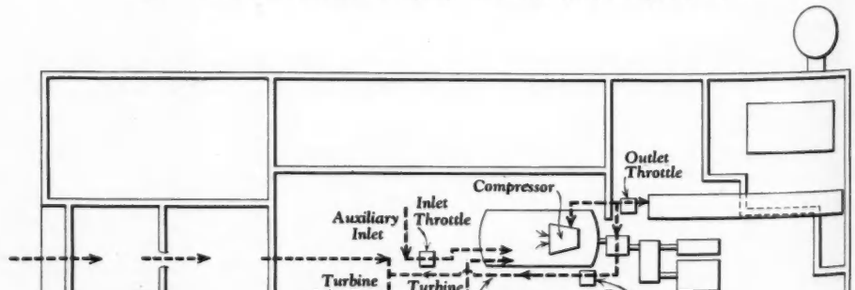



Fig. 2 Plan showing ducting for " cold " turbine tests. A compressor is used to provide suction. Warm air for the turbine entry is provided by mixing hot air from the compressor exit with the atmospheric air, thus preventing ice formation at the turbine outlet.

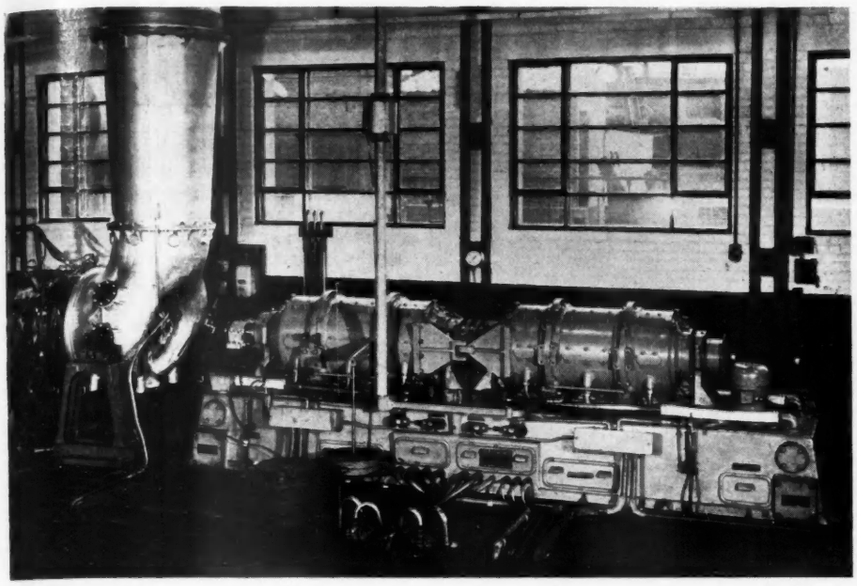


Fig. 4 Turbine test rig; two Heenan-Dynamatic 2,000-h.p. dynamometers control the turbine speed.

supported by three struts attached to the cell wall. The drive shaft passes through this housing and is supported in a bearing at each end. Leakage of air into the cell through the transmission unit is prevented by a labyrinth seal. A coupling flange on the forward end of the drive shaft is connected through a flexible coupling to the compressor shaft. Lubrication for the bearings of the transmission unit and for the compressor under test is supplied from two separate oil systems outside the cell.

## TURBINE TEST RIG

In the turbine test rig, shown in Fig. 4, the turbine is supported in a volute to provide uniform velocity distribution at the entry. The volute is trunnion-mounted on pedestals to allow for thermal expansion. The turbine itself is coupled to the Heenan and Froude Dynamatic dynamometer through a flexible coupling. Depending on the type of turbine being tested, the dynamometer can be run as a single unit of 2,000 h.p., or the two units can be coupled together in tandem to provide a 4,000-h.p. unit.

The turbine test rig is driven by air supplied by the engine compressor installed in its cell. It will be seen from Fig. 2, which shows the layout of the air-ducts supplying the turbine, that the compressor cell is connected by a suction duct to the outlet of the turbine so that the compressor sucks air through the turbine and exhausts it to atmosphere through the compressor outlet throttle valve and ducting. This method of carrying out turbine tests conveniently limits the power which has to be absorbed by the dynamometers, and has the additional advantages that instrumentation is simplified, and that new forms of blading in easily-manufactured materials can be investigated.

The turbine inlet duct is coupled through an elbow joint to the roof inlet ducting behind the nozzle chamber, so that the pressure at the turbine inlet is just below atmospheric. The compressor inlet duct is coupled also to an auxiliary air inlet which, in addition to preventing surging of the compressor, provides a means of setting the turbine at a given working point.

The turbine inlet temperature is regulated by an adjustable bleed valve which allows some of the hot air from the compressor exhaust to mix with the cold air entering through the atmospheric inlet. A measuring nozzle in the hot bleed duct enables the quantity of hot air fed to the turbine to be metered. By this means the turbine outlet temperature can be kept sufficiently high to avoid ice formation at the turbine exit.

In the case of certain turbines where it is desirable to test under engine-operating conditions of temperature and pressure, the ducting may be readily modified with the addition of a combustion system.

## DYNAMOMETER CONTROL

The speed at which the turbine runs is controlled by the Heenan and Froude eddy-current dynamometer. This is similar in principle to the standard production Heenan-Dynamatic machine, apart from the fact that the control gear is fitted with extensive protective devices and that a specially designed high-speed rotor capable of absorbing considerable power is employed. The dynamometer load is measured by Heenan hydraulic weighing gear.

The dynamometer is provided with two different power/speed characteristics – the "constant speed" or "propeller law" characteristics – either of which can be remotely selected. With the constant speed system in operation, the rotational speed remains unaltered even with a considerable change in the mass flow through the turbine, the dynamometer adjusting its load automatically to suit the power output with only very slight corresponding speed change. Alternatively, by operating a speed-control handwheel, the engine can be tested over a range of speed at almost any throttle opening.

If, however, the speed is controlled under "propeller law," then at any given setting of the dynamometer load-control gear an alteration in the engine throttle opening will cause a change in the dynamometer load and speed so that the power will vary approximately as the cube of the speed.

Automatic protection is provided against overspeeding, failure of the dynamometer cooling-water supply, an excessive rise in bearing temperatures, or failure of the electrical main. In the latter case an auxiliary direct-current supply is automatically switched in from batteries. This provides emergency direct-current excitation to the dynamometer and brings it to rest.

## STEAM PLANT

Steam for the high and low-pressure marine steam turbines which drive the test compressor is supplied by an oil-fired boiler capable of producing 100,000 lb. per hour of steam at 650 deg. F. and 300 lb. per square inch. Steam can be raised in 2½ to 3 hours, starting from cold. A closed-feed system is employed.

The stokehold is pressure-charged to 7 in. of water at full load by a steam-driven fan and an electrically-driven fan. To avoid loss of pressure, access to the boiler room is through a revolving door and air lock.

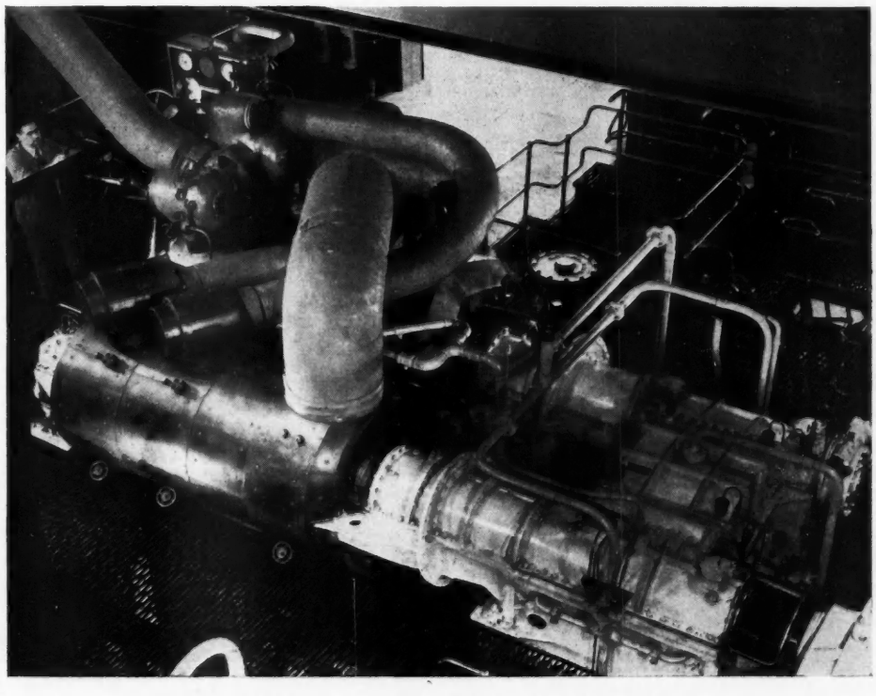


Fig. 5 10,000-h.p. steam turbine set from Hunt-class destroyer.

**Fig. 6 Control room, from which rotational speed and pressure ratio are regulated.**

The high and low-pressure turbines, shown in Fig. 5, operate at the same speed and are coupled together by a marine gearbox, the output of which drives a speed-increasing gearbox through a flexible coupling. The maximum power output of the plant is 10,000 h.p. at 3,650 r.p.m. The speed-increasing gearbox can be fitted with alternative gears to give a final maximum drive speed of 16,500 r.p.m., or 11,000 r.p.m. The output shaft is flexibly coupled to the transmission unit in the compressor cell.

The low-pressure steam turbine exhausts to a condenser situated below it. The condenser cooling water is pumped, at a rate of 9,000 gallons a minute, from a 600,000-gallon artificial lake in the grounds; after circulating, the cooling water is pumped back to the lake through sprayers for evaporative cooling.

The various auxiliaries, all of which are steam driven apart from one electrically-driven fan and the auxiliary fuel-oil feed pump in the boiler room, are housed in an auxiliary engine room. Part of the exhaust from the auxiliary-drive turbines passes through a heat exchanger which raises the temperature of the feed-water before it enters the boiler; the other part passes to the condenser. The boiler feed water is distilled in a ship's evaporator from water taken from the cooling lake, before being used for the boiler. All the water in the lake is chemically softened in the automatic softening plant. A donkey boiler supplies steam for heating the evaporator the fuel-oil storage tanks and the building.

## CONTROL AND CAMERA ROOMS

During a test, no personnel are present in the test chamber itself, the regulation of rotational speed and pressure ratio being directed from the main control room (Fig. 6) on the ground floor. An inter-communication system is provided to enable the test controller to give instructions to the engine room crew and other test personnel. Above the main control room is the camera room containing 300 in., 200 in., 100 in., and 40 in. mercury and water manometers, to which all the pressure tappings on the compressor, the ducting and the turbine inlet and outlet are connected. Both upper and lower control rooms are acoustically treated with Cellotex tiles.

The camera room (Fig. 7) is equipped with five automatic recording cameras, any of which can be selected from a control panel in the main control room, the manometers being illuminated from back-lighting panels also controlled from the camera control panel.

On the main control panel are located the switches for the electrically-operated throttle valves in the ducting, speed indicators for the compressor and the turbine test-rig, and the dynamometer control for the latter, and pressure gauges for use in setting up the test.

An oscilloscope on the controller's panel records the indications from a seismic vibration pick-up during the test. Should undue vibrations be indicated, the plant can be shut down by an emergency switch which automatically shuts down the steam turbine.

## ADJUSTABLE OUTLET-PRESSURE PICK-UPS ALIGNED BY SELSYN UNITS

In measuring the turbine outlet pressure it is essential that the pressure pick-ups are correctly aligned with the direction of the air flow which varies with the turbine speed. The pressure pick-ups at the turbine outlet are therefore adjustable and are driven by Selsyn units, which can be operated remotely from the control room to the correct setting for each turbine speed.

On another control panel are located the remote temperature indicators for the compressor and turbine inlet and outlet temperatures. Platinum resistance wire thermometers are provided in the compressor cell and in the ducting at the measuring nozzles. The readings from these can be selected and read on a direct-reading Elliott indicator. For measuring the outlet temperature of the hot gases, copper/Constantan thermocouples are employed, in conjunction with a Negretti and Zambra potentiometer indicating in millivolts, a conversion chart being used to give the temperature.

An engineer's panel is also provided, in which are recorded the temperatures and pressures of the lubricating oil in the transmission-shaft, compressor, turbine and dynamometer bearings; and the dynamometer oil and cooling water temperatures. The controls for the compressor and turbine oil heating are on this panel, as are also the warning lights for the dynamometer cooling-water supply and oil pressure.

## TEST PROCEDURE

In conclusion it may be of interest to outline the test procedure. In investigating the compressor component of a gas turbine engine one of the most useful tests is to obtain characteristics, at values of constant non-dimensional rotational speed (i.e., the actual speed corrected for the ambient temperature conditions), of the variation of overall pressure ratio and adiabatic efficiency against mass flow. To do this, the compressor under test is run up to the value of speed giving the desired non-dimensional speed. The outlet throttle in the exit duct from the compressor is

**Fig. 7 Camera room equipped with five automatic cameras for recording manometer readings. Back-lighting panels illuminate the manometers.**

then progressively closed, observations being made at suitable intervals to give both the overall and detailed stage performance.

The closing of the outlet throttle raises the back pressure on the compressor until a value is reached at which the compressor stalls. A typical set of observations takes approximately five minutes to complete while a complete set of characteristics involves two to three days work. All the observations for a set of test observations are photographed simultaneously in the camera room by remote control from the main control room.

When it is required to test under altitude inlet conditions it is necessary progressively to close the throttle in the inlet duct to the compressor as the compressor is run up to the desired speed. With the inlet throttle then fixed the curve is obtained by the same method as previously described.

For turbine testing, a compressor, installed in the test cell, is run at the speeds necessary to induce through the turbine under test the required air flows. Tests usually take the form of constant non-dimensional speed characteristics or, alternatively, constant pressure-ratio characteristics. Observations of overall and detailed stage performance are made at suitable intervals and are photographically recorded. When desired, a turbine with output within the capacity of the dynamometer system can be tested by the alternative means of heating high-pressure air from the compressor in a combustion system before passing through the turbine.

# MECHANICAL CHARGING OF IRON FOUNDRY CUPOLAS

In recent years, various sections of the Farington foundry of Leyland Motors Limited, Leyland, Lancashire, including the filling and packing of moulding boxes and the reclamation and mixing of the moulding sands, have been mechanised, and the process has now been extended to the charging of the cupolas by the installation of a mechanical handling plant in the foundry stockyard. A general view of the new plant is seen in the illustration on the right.

Stocks of pig-iron, scrap and other ingredients for producing iron castings are stored in separate piles in the stockyard, and working quantities of these are transferred from the stock piles by means of a 5-ton gantry crane to walled-off containers or bins flanking both sides of a miniature railway line. Along this track runs a mobile weighing machine, built to carry the specially-designed drop-bottom metal container or skip, seen in the illustrations below. As the weighing machine is moved along its track the skip is loaded with the correct weight of various grades of pig-iron, limestone and other raw materials from the containers alongside. At the end of the track, coke is weighed into the skip from an overhead hopper which has a capacity of 12 tons. All the loading is carried out under cover and an important feature of the arrangement is that the height of the top of the skip as it travels on the mobile weighing machine is level with the platforms of the containers on which the working quantities of raw materials are segregated. This facilitates the loading of the material into the skip and avoids unnecessary lifting.

After receiving its charge, the skip is propelled along a roller conveyor to a position below a hoist and telpher which raises it and then conveys it at a speed of 300 ft. a minute along a mono-rail and branch-rail system to one of four cupolas into which the contents are discharged through the drop bottom of the skip. The empty skip is then taken to another roller conveyor along which it is gravity-propelled to the end of the track of the mobile weighing machine. The process is thus continuous. A number of skips are in circulation at the same time, one leaving the loading bay every six minutes.

The new installation not only greatly reduces the man-hours required for loading but ensures more efficient quality control, improved charging in the iron foundry, in which the weekly melting rate is upwards of 200 tons, and a higher factor of safety for the men employed ; it has been planned by Leyland Motors Limited, and constructed and installed by the Paterson Hughes Engineering Company, Limited, Wyndford Works, Lochburn-road, Maryhill, Glasgow, N.W.

## SWARF BRIQUETTED FOR CUPOLA

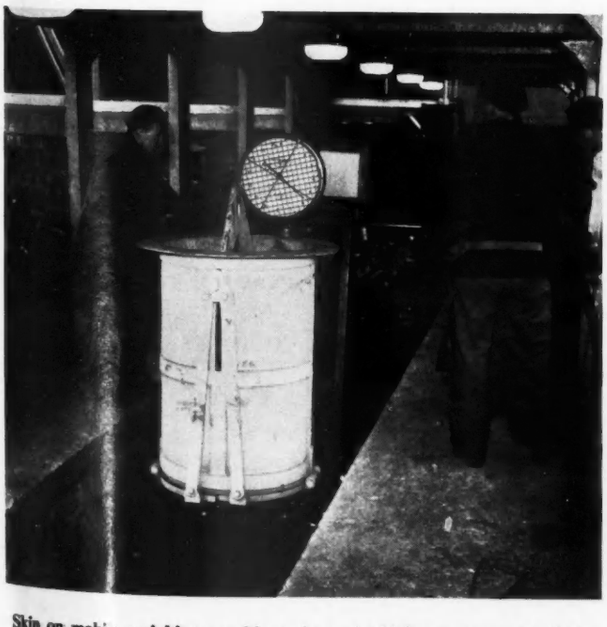
Working in conjunction with the new installation is a plant for the manufacture of cast-iron briquettes from turnings and borings. It is capable of dealing with 20 tons of iron swarf in a 44-hour week and of producing 2¼-lb. briquettes, at the rate of 540 per hour, by compression in a toggle press supplied by William Johnson and Sons (Leeds), Limited, Leeds, 12. The applied pressure is 250 tons and the density of the briquettes as compared with iron, as-cast, is 70 per cent.

* * *

## HIGH-STRENGTH ALUMINIUM CASTING ALLOY

The final details of an agreement between the Frontier Bronze Corporation, Niagara Falls, U.S.A., and Daralum Castings, Ltd., Longfield-road, Darlington, have now been settled. The agreement gives the British firm the exclusive rights to manufacture and apply the high-strength aluminium alloy known as Frontier 40-E in Great Britain. Arrangements have been made for ingots of the alloy to be manufactured by John E. Moore, Ltd., Yeadon, Yorkshire, and it is the intention to grant sub-licences to approved foundries in due course. The major constituents of the alloy comprise: zinc, 4·75 to 5·75 per cent.; magnesium from 0·40 to 0·60 per cent.; chromium from 0·40 to 0·60 per cent.; and titanium from 0·15 to 0·25 per cent. Very narrow limits are placed on all impurities.

After ageing at room temperature for 21 days the following minimum mechanical properties are attained. Yield point: 13 tons per square inch; ultimate tensile strength: 16 tons per square inch; elongation: 5 per cent., and Brinell hardness number (load 500 kg., 10 mm. ball) 75. A short period of artificial ageing at 180 deg. C. may be substituted for the natural ageing period. The alloy was first introduced in 1944 and tests carried out over eight years have shown that it remains stable and has excellent corrosion-resisting and stress-corrosion resisting properties. Its machinability is claimed to be superior to that of most other aluminium casting alloys.



**Skip on mobile weighing machine; the waist-high arrangement of bins and skips obviates the necessity for excessive lifting.**

**This cupola-charging plant in a foundry stockyard reduces the man-hours required for loading and improves quality control.**

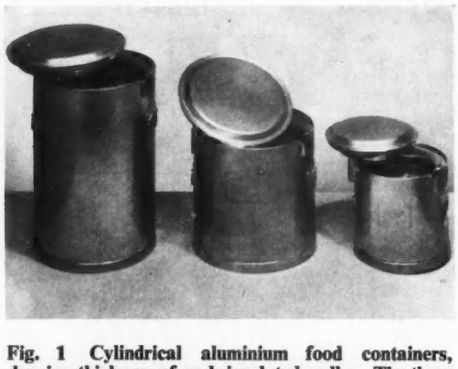


Fig. 1 Cylindrical aluminium food containers, showing thickness of cork-insulated walls. The three standard sizes have capacities of one, three and five gallons.

Fig. 2 Rectangular container. The steel handle and hinge are secured by rivet-headed studs spot welded to the aluminium to avoid piercing the sheet.

# PRODUCTION OF ALUMINIUM FOOD CONTAINERS

After the War, makers of aluminium were busy seeking new applications for this light-weight material. It had long been used in the manufacture of containers in which food is cooked, and in 1948 it was first used in this country for quantity production of insulated food containers of the type shown in Figs. 1 and 2. The containers are bought by the Government for use in centralised kitchens where meals are prepared and distributed to schools. They are being made by Grundy (Teddington), Limited, Somerset Works, Teddington, Middlesex, by semi-line production methods. At present, 700 rectangular containers and 2,000 cylindrical containers are being made each week. Since production commenced, over 400,000 containers have been made by this company alone. The material from which they are made is supplied by the British Aluminium Company, Limited.

When they received the first order in 1948, small though it was, the firm decided to tool up for bulk production with the idea of reducing costs and maintaining a consistent standard of quality. The use of aluminium resulted in a saving in weight – an advantage in view of the fact that containers are usually handled by women.

Each container is insulated by granulated cork. This is packed between the inner and outer skins of the drum, lid and base, and all three are hermetically sealed by butt welds running around their outer edges. The insulated wall is about 1 in. thick. All the welding is carried out by women trained by the company. The edges of the container are spot-welded together before the actual welding of the seam is carried out, so that clamps and jigs can be removed. After sealing they are immersed in water at 195 deg. F. for five minutes to test for cracks or other holes that may be present. This is essential since the containers are cleaned out frequently in use.

## METHOD OF FIXING HANDLES

In the original design the hinges and catch-plates were riveted to the container, but this method of construction had one serious disadvantage – the rivet holes tended to pull out as they had to take most of the load when the containers were being carried. It was evident that piercing of the inner and outer skins for rivets or bolts should be avoided. To solve this problem spot stud welding methods were introduced, and recesses were formed in the outer skin for the lifting handles as an additional protection against damage in transit. This also made stacking easier.

The fitments used, such as handles and hinges, are made from mild steel cadmium-plated. Aluminium studs are headed and pressed into the rivet holes of the handle-bearing plates. These are then placed in position on the outer surface and the welding electrodes are applied to the head of the studs and the inside of the container to fuse the studs in position. As can be seen from Fig. 2 the appearance is that of a normally riveted joint, but it is said to be stronger and more serviceable.

## CONTINUOUS ARGON-ARC WELDING

The outer casing is made from 16 s.w.g. aluminium sheet, guillotined to size, flanged on brake presses and formed into a box shape with a hardwood tool on a Ceco stamp. The flanged ends are milled to remove the oxidised surface, and the seam is then argon-arc welded in a machine which has been designed and built by the company. It is illustrated in Fig. 3. On the right the operator is feeding the drum to the milling cutter. In both machines the feed is by friction rubbing wheels.

The welding machine on the left has its speed governed, and a wire buffing wheel gives a final cleaning to the area surrounding the flanges before they pass beneath the welding torch.

After this operation the recesses for the handles are pressed in. The recesses can be seen in the rectangular container shown in Fig. 2.

Fig. 3 Milling and argon-arc welding of cylindrical shells.

In Fig. 4 one operator is loading cast-aluminium sleeves, which carry a lock spring and clamp, into a jig while her partner spot welds them into position.

The inner casing is formed in a similar manner to that of the outer casing and is pressed into position, the space between being filled with the granulated cork, which is fed from an overhead hopper. Skids are formed along the inner surfaces of the container to give line contact and reduce heat loss through conduction. Similar skids are also spot welded to the outer surface.

The bottom is pressed in and top and bottom seams acetylene welded with 99 per cent. pure aluminium rod. The lid is made from two 16 s.w.g. pressings, and the hinge and unusual design of lever handle, which are spot welded to its outer surface, can be seen in Fig. 2. The two pressings are loaded with cork and gas welded together and finally tested for leaks.

## STANDARD SIZES

There are four standard containers, one rectangular measuring 11 in. by 10¼ in. by 17½ in. deep inside, and three cylindrical of one, three and five gallons capacity. The containers are fitted with trays from which the cooked food is served direct on to the children's plates.

Fig. 4 The operator on the right is fitting aluminium bushes into an outer casing, which is held in a jig. The other operator is spot-welding the bushes in position.

# TSETSE FLY CONTROL

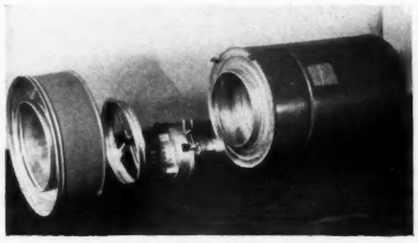
## AERIAL RELEASE OF INSECTICIDAL SMOKE

About four million square miles of the more fertile part of Africa is at present rendered useless for development by the presence of the tsetse fly, carrier of trypanosomiasis, or sleeping sickness. Many methods of attack have been put forward or tried, and now it is proposed to use pesticidal smoke from canisters distributed by air. Tiltman Langley Laboratories, Limited, Redhill Aerodrome, Surrey, have been carrying out the investigations, with the co-operation of Imperial Chemical Industries, Limited, Lea Bridge Industries, Limited, the Metal Box Company, Limited, and Smiths English Clocks, Limited.

Briefly, the chemicals to generate the smoke will be enclosed in a metal container, complete with time-delay mechanism and percussion cap. A second container carrying a small parachute will be clipped on to the first. The various parts of the generator are shown in the photographic illustration and a diagrammatic arrangement is shown below. The total weight of the bomb is 7 lb., 6 lb. of which is the burning mixture; it is 10½ in. high and 6¼ in. in diameter. The parachute is 21 in. in diameter and limits the rate of fall to approximately 50 ft. per second; during tests, the canisters withstood drops of 400 ft. on to concrete.

### DISTRIBUTION BY AIR

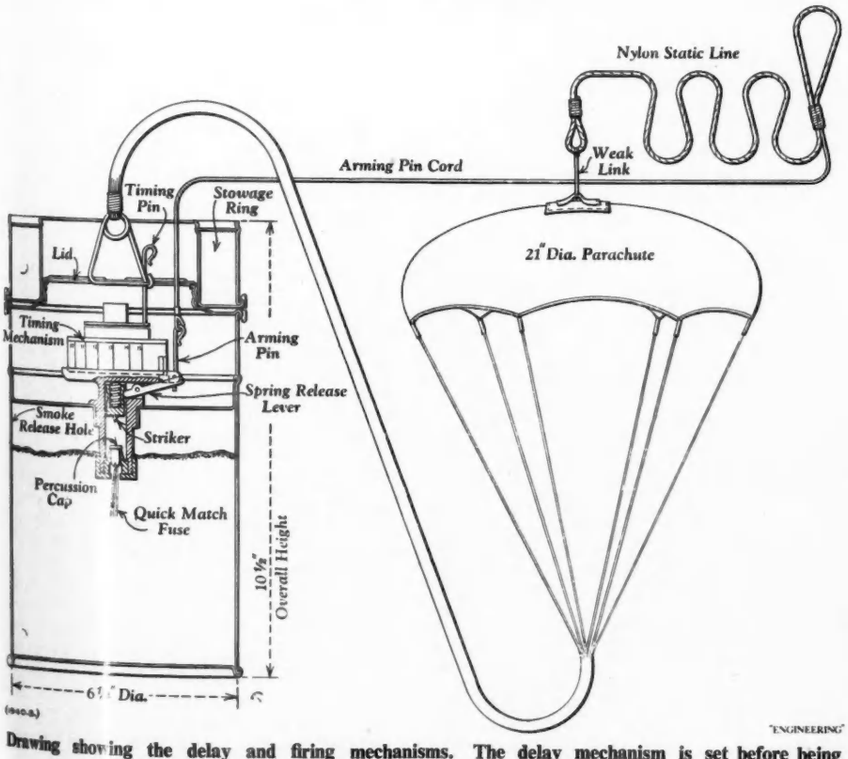
It is proposed that the canisters shall be distributed over the area by dropping them from an aircraft. For this, Bristol Freighters could be used, operating from aerodromes along the railways which lead inland from Mombasa and Dar-es-Salaam, or flying-boats (Sunderlands or Catalinas) based on harbours or lakes. Lakes Rudolph, Victoria, Albert, Tanganyika and Nyasa would be bases bringing a large area within reach. The timing mechanisms in the



**The parts of the smoke generator: left to right, parachute stowage ring, the lid, the delay timing mechanism and the chemical container.**

canisters, which have a maximum of 14 hours, would be set so that the explosions would take place as nearly as possible at the same time, and the timing pins removed, this being done before take-off. The canisters would be placed on a conveyor belt running the length of the aircraft, which would feed them out at regular intervals; about 1,285 canisters would be distributed over 12 square miles. The distribution pattern would, of course, be varied to suit the local conditions.

The delay timing mechanism is set before being screwed into the body, the striker being held by the spring-release lever. The latter is held locked by the arming pin, which is not pulled out until the bomb is actually dropped. The lid, which has four large holes cut in it, is then screwed on and the upper section, with the parachute and its cords stowed in it, clipped in place. Design of the canisters was controlled by the fact that they would have to stand up to African sun and heat, and also to being dropped in streams and marshes. Investigations are being made into the possibility of using a radio-controlled fuse, so that the bombs could be detonated from a distance. This would have the two added advantages that all the bombs would explode together, thereby forming a continuous smoke layer, and also that they could be dropped at some convenient time but not exploded until the weather conditions were favourable.




**Drawing showing the delay and firing mechanisms. The delay mechanism is set before being screwed into the body, but does not start till the timing pin is removed.**

* * *

# FAST UNLOADING OF LORRIES

## *Hydraulically-Operated Tipping Platform*

A hydraulically-operated tipping platform for unloading lorries has recently been developed in the United States by the Link-Belt Company, Chicago 1, Illinois. In its largest form, it can end-tip lorries and semi-trailers whose length is up to 54 ft. with a total weight of 80,000 lb. This tipping platform consists essentially of a platform built from steel joists, with one end hinged to an anchorage at ground level and the other end arranged to be raised hydraulically to give a maximum slope of 40 deg. to the horizontal.

A vehicle to be unloaded is driven on to the platform and secured in position by hydraulically-controlled stops that block the rear wheels of the lorry thereby preventing it from running backwards as the forward end of the platform is raised. Elevation is effected by two four-sleeve hydraulic telescoping cylinders, which are pin-connected to the apexes of A-frames attached to the platform on either side at a distance from the rear hinge approximately equal to two-thirds the length of the platform. The bases of the cylinders are fixed at ground level and arranged to pivot to allow for the constantly changing angle as the platform rises and falls.

Power to operate the hydraulic cylinders is provided, in the largest model, by two electrically-driven 20-h.p. hydraulic pumps which, when working together, enable a vehicle weighing 80,000 lb. to be elevated to an angle of 40 deg. to the horizontal in one minute ; the time taken to lower a vehicle is 40 seconds. Remote control of the hydraulically-operated stops and of the main elevating cylinders is fitted and permits of one-man operation.

A feature of the installation is that none of the mechanism is below ground level, which facilitates both installation and maintenance.

* * *

# AUTOMATIC LOADING HOIST

## Charging Electric Furnaces

Primarily designed for charging electric furnaces, a mechanical hoist which can be adapted for any similar purpose is made by Funditor, Limited, 3, Woodbridge-street, London, E.C.1. The standard model is designed for use with their 1-ton electric furnace. It consists simply of two upright girders at the top of which is mounted a 1-h.p. motor driving the hoisting winch; overall the height is 10 ft.

Loaded skips are pushed to the bottom of the girders, and the handles swung over to engage with the hoisting gear. Raising and lowering are controlled by push-buttons. As the skip rises, the upright girders act as guides to keep it level until lugs are engaged on the side which cause the skip to tilt and to discharge its contents into the furnace. Other lugs cause the furnace lid to open in time to receive the charge. The sequence is reversed when the skip is lowered. With a capacity of 10 cwt., this hoist reduces the physical labour required to keep the furnace charged.

# 135-TON WAGONS FOR BRITISH RAILWAYS

## *Transport of Large Power Transformers*

The increasing bulk and weight of electrical equipment, especially of large power transformers, which cannot be sectionalised, is offering a difficult problem to transport authorities. An example of what is being done in this direction is provided by two wagons built for British Railways by Head, Wrightson and Company, Limited, Thornaby-on-Tees, for the conveyance of transformers by rail.

### CONSTRUCTIONAL DETAILS

These vehicles, one of which is shown below, weigh 72½ tons. They are capable of carrying a load of 135 tons concentrated on the two main side beams at 20 ft. centres or on three points at 30-ft. centres. They can also carry a distributed load of 120 tons over a length of 30 ft., or of 100 tons over a length of 12 ft. They are 92 ft. long over the buffers and 89 ft. long over the headstocks. They provide a clear loading space 30 ft. long and from 6 ft. 11 in. to 9 ft. wide between the side beams on which the load is supported. Loads considerably more than 9 ft. wide can, however, be carried above the beams.

As regards construction, each wagon comprises two main side beams, which rest on an equalising beam at each end, the latter being supported, in turn, on two six-wheeled bogies. Each side beam is 9 in. wide and 3 ft. 9¾ in. deep at the centre, while the distance between the centres of the supports is 60 ft. They are both detachable and can be moved so that the distance between their flanges can be adjusted from 6 ft. 11 in. to 9 ft. in steps of 5 in. Their height above rail level varies from 7 ft. 11½ in. when unloaded to 7 ft. 9½ in. when loaded.

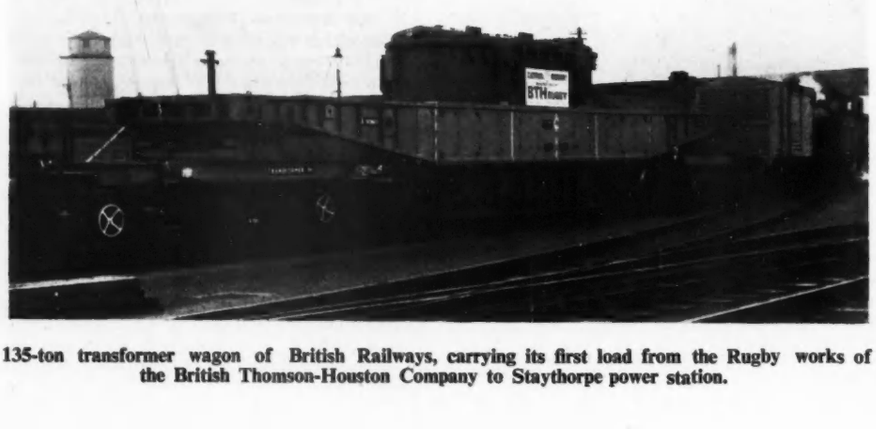
The beams are fabricated and consist of two web plates separated by vertical rolled-steel joists. These joists are covered top and bottom by flange plates which are welded to the web. Both beams are secured to an end connection framework through cast-steel clutches, and the framework of each end connection is fixed to the top of a structure containing the equipment for adjusting the side beams as well as cross-traversing gear. This gear enables the side beams with the transformer mounted on them to be simultaneously traversed on steel rollers up to a distance of 12 in. on either side, thus permitting obstructions to be avoided during transit. It runs in an oil bath and can be operated from either side of the vehicle through a screw and trunnions.

Steel centre castings, which are steadied by friction side plates, are incorporated in this structure, the arrangement being such that the weight is carried on an equaliser at each end and that the load is transmitted equally from the side beams to the two bogies at each end. Steel centre castings and side friction blocks are provided at each bogie centre.

### BOGIE DESIGN

The six-wheeled bogies are built up of riveted rolled-steel sections and plates, the wheels being 3 ft. in diameter. A screw brake, which can be operated from either side of the wagon, is provided and actuates two blocks on two wheels of each bogie. The main bearing springs are laminated, while the auxiliary springs are of india-rubber. The vehicles are, of course, of standard gauge and are capable of negotiating curves of 1½ chains radius. Jacks are fitted so that the beams can be relieved of the weight of the transformer. One beam is then removed on detachable legs, which run on rollers over a temporary rail at ground level, so that the transformer is drawn out.

The illustration shows one of these wagons making its first journey on Thursday, January 28. The load consists of a transformer weighing 119 tons, which is being taken from the Rugby works of the British Thomson-Houston Company to the Staythorpe power station of the British Electricity Authority.



**135-ton transformer wagon of British Railways, carrying its first load from the Rugby works of the British Thomson-Houston Company to Staythorpe power station.**

# MECHANISATION FOR THE BUILDING CONTRACTOR

## DEMONSTRATION OF THE FERGUSON SYSTEM

**3-ton road roller driven from the rear wheels of a tractor mounted on it.**

★ ★ ★

THE wide range of implements that are used with the Ferguson tractor was demonstrated on January 27 and 28 by Eastern Tractors, Limited, Springfield, who are the main dealers in Essex for Harry Ferguson, Limited, Coventry. The purpose of the demonstration was to show how greater mechanisation could aid the building and municipal contractor by saving time and reducing labour costs, and it was attended by local authorities and contractors in the area. Among the various items of equipment demonstrated was the Taymen post-hole borer and pole erector illustrated and described on the opposite page. The standardisation achieved among the various items of equipment demonstrated was such that with careful planning one tractor could be kept in practically constant operation, on a building site, by moving it from one machine to another in strict rotation.

### ROAD ROLLER

The illustration on the left shows a small road or sports-ground type of roller made by E. V. Twose, Limited, Tiverton, Devon. The tractor is reversed up ramps on to the chassis to the position shown. The rear wheels are then jacked up by the tractor's hydraulic lift so that they clear the frame. The drive is taken from two sprockets, bolted to the rear wheels of the tractor, by a chain to a driving shaft which is coupled to the rear rollers. As the drive is taken off each of the rear wheels the differential gear of the tractor functions in the normal manner when cornering. Likewise the brakes on the rear wheels of the tractor serve to bring the roller to a standstill; as the reduction ratio of the drive to the roller is 2 to 1, the braking efficiency is particularly good.

A separate steering column is fitted and this is arranged to project up between the spokes of the normal steering wheel It is connected to the front roller by a heavy-duty chain. An independent parking brake is fitted, and a towing arrangement can be attached to the front of the roller chassis should this be required. The ramps used for mounting the tractor are stowed on the chassis in a convenient position.

The design of the chassis follows normal roller practice and a 34-in. wide steering roller is used at the front and two 24-in. wide driving rollers at the rear. The three rollers give a coverage of 6 ft. The normal load on the rollers is 2 tons 17 cwt.; to increase this the rear rollers can be filled with oil and water ballast to give a total weight of 3 tons 9 cwt. The time taken to mount the tractor on the roller frame and couple the driving and steering gear during the demonstration was about 10 minutes.

### HIGH-LIFT LOADER

Another implement displayed was the Ferguson high-lift loader, which has a discharge height of 8 ft. 6 in. and a capacity of one-third cub. yard, equivalent to 10 cwt., when fitted with the bucket attachment shown opposite. The hydraulic pressure for operating the lift is taken from a pump fitted in the chassis of the tractor. The hydraulic cylinder controlling the bucket movement allows the load to be dumped gradually; this prevents the floors of trailers being damaged. The bucket can be replaced when required by other attachments for farm work. A small lever for controlling the movement of the bucket is mounted alongside the driver.

**A tipping trailer is coupled to the tractor, which is fitted with a high-lift loader having a capacity of ⅓ cub. yd. and a discharge height of 8 ft. 6 in.**

A trailer was hitched to the back of the tractor demonstrated with the high-lift loader. It carried a maximum load of 3 tons and took its hydraulic feed for the operation of its tipping gear from the tractor. The tractor used was fitted with dual rear wheels for soft ground.

Among the other items of interest displayed was a machine for digging trenches to a depth of 8 ft. 6 in. and a width of 2 ft., made by John Allen and Sons (Oxford), Limited; an "Atlas" portable air compressor; a mobile self-loading elevator for transferring free-flowing loose bulk material from heaps to waiting vehicles, made by Modern Plant Autoloaders, Limited, Billesdon, Leicester; and a cement mixer which could be attached to the rear of the tractor, made by Tamkin Brothers and Company, Limited, Heybridge Works, Maldon, Essex.

# POLE-HOLE BORER

## ERECTION OF TRANSMISSION LINES

The pole-hole borer shown in the two illustrations has been developed for the specific task of assisting in the erection of electricity-supply lines in country areas. The machine, designed by Mr. J. V. Taylor of Taymen Limited, Kingswood, Surrey, who will make and market it, was developed in conjunction with Mr. L. Fisher, engineer to the Surrey area of the South Eastern Electricity Board. The particular problem in this area involves running extension lines requiring, on the average, not more than eight or nine poles to outlying farms. For this purpose the heavier pole-hole borers mounted on the back of four-wheel or six-wheel lorries are not suitable, being altogether too large and heavy to manœuvre in farm lanes and across cultivated land. The "Taymen," light enough to traverse a ploughed field, is capable of handling 36-ft. poles – the standard for this type of work – at the rate of nine or ten per day. The actual time for boring a hole, lifting and plumbing a single pole is about half-an-hour.

The boring machine is built on a standard Ferguson tractor; the model used is petrol driven and develops 30 brake horse-power. To this tractor has been fitted a "Horn Hydraulic" jib made by Steel Fabricators (Cardiff) Limited; it has a lifting height of 20 ft. and is easily able to handle the maximum weight of 6¾ cwt.

The borer, as can be seen from the illustrations, has been fitted on the rear of the tractor, and is driven by a closed oil circuit. The pump, which delivers 14 gall. per min. at its optimum speed of 1,500 r.p.m., is driven by the power take-off of the tractor and the oil is conveyed by flexible hoses to the hydraulic motor; both the pump and the motor are "Deri Sine" supplied by Andrew Fraser and Company, Limited, London, S.W.1. This motor drives the auger shaft directly. The boring frame is simple and robust, being welded from rolled steel angle and plate, and it is fitted with two foot plates to give it added stability during the boring operation. The roller bearing supporting the auger shaft has been kept simple and unprotected so that it can be cheaply and easily replaced, the view being that this is better than attempting to shroud the bearing and keep the dirt out.

The form of auger used is still a matter for review, but a flat plate type 18 in. in diameter with a fine lead is preferred. The blade tips are renewable and the auger plate can be easily removed by undoing the holding bolts. A hole 5ft. 6 in. deep can be drilled without touching the standard arrangement, but an additional 12 in. can be gained by lowering the guide halter to ground level; this can only be done after the auger has penetrated the ground.

### BORING ON A SLOPE

The necessary adjustments have been provided so that a plumbed hole can be bored with the tractor standing on a considerable slope, as is shown in the second illustration. Both the boring frame and the crane jib can be quickly dismantled.

The photographs were taken during a demonstration in the grounds of the S.E.E. Board's headquarters at Rough Rew, Dorking, and not during the progress of actual work. This accounts for the plain pole being handled; it is, of course, the usual practice to erect the poles all prepared to receive the insulators and wiring.

**The auger, 18 in. in diameter, can be driven to a depth of 6 ft. 6 in. Mounted on a Ferguson tractor, the "Taymen" pole-hole borer has a greater accessibility than heavier, lorry-mounted types.**

**With a crew of two or three men, the tractor-mounted pole-hole borer enables the hole to be bored and a 36-ft. pole for transmission lines erected in about half-an-hour.**

**"Reciprojet" self-cleaning air filter. A double column of filter cells, mounted on an endless chain, is advanced at intervals to bring the dirtiest cell under the scouring action of four oil jets.**

## SELF-CLEANING AIR FILTER

### *Reciprocating Oil Jets Clean Cells*

For use in plants where atmospheric dust is exceptionally prevalent, such as steelworks, collieries, cement works, etc., an automatically self-cleaning air filter, with two stages of filtration, has been developed by the Visco Engineering Company, Limited, Stafford-road, Croydon. The filter, known as the "Reciprojet," comprises a double column of filter cells, which are cleaned by four reciprocating oil jets controlled by a time switch.

The Reciprojet consists of one or more filter sections of various heights, according to the capacity required. Each section comprises a mild-steel frame with two columns of oil-wetted metal filter cells supported in carrier plates attached to two endless chains. At the base of each section is a large oil tank.

At predetermined intervals an electrical time switch starts a fractional horse-power motor driving the filter columns, and an oil-pump motor. This brings the dirtiest cell in each section into the cleaning position. Here, it is scoured by oil jets which move backwards and forwards across the width of the cell. The dirty cell is initially tilted to allow the oil to wash the dirt forwards and downwards through the cell plates. As the cell continues to move, the jets scour the front dirty face. When the filter columns have advanced by one cell spacing, a limit switch is arranged to cut out the filter and oil-pump motors.

The oil in the system is passed through an oil strainer unit, the capacity of which ensures that all the oil is cleaned at least once between each spraying operation. The dirty oil remains in the filter tanks, in which the sludge settles. The sludge can, if desired, be drained to a central settling tank.

The filtration efficiency is considerably improved by the double column of cells through which the dust-laden air has to pass. Since the cells in the column on the clean air face have been previously in use on the up-stream side of the filter, the oil coating on the cell plates will have dried to some extent, and the cells will act as a trap for any oil carry-over.

## TRACTION ENGINE FOR THE SCIENCE MUSEUM

The Science Museum, South Kensington, London, S.W.7, has been recently presented by the Road Locomotive Society with one of the earliest traction engines ever constructed, an Aveling and Porter single-cylinder engine of 8 nominal h.p. built at Rochester, Kent, in 1871 and numbered 721.

Records relating to engine No. 721, now in the possession of Aveling-Barford, Limited, show it was dispatched in 1871 to an owner in the south of England who, after it had given him many years of service, became so attached to it that he had it reconditioned regardless of cost rather than purchase a new one. Later, the owner's estate was broken up and the engine passed to an owner in Kent, where it remained until the Road Locomotive Society found it last year in an advanced state of dilapidation. Through the good offices of Aveling-Barford, Limited, No. 721 has been completely restored, as the illustration shows, so that it now looks much the same as it must have done eighty-three years ago. Fitted with an electric motor, this old engine will now provide a working exhibit in the new gallery of the Science Museum, which is approaching completion and will shortly be opened to the public.

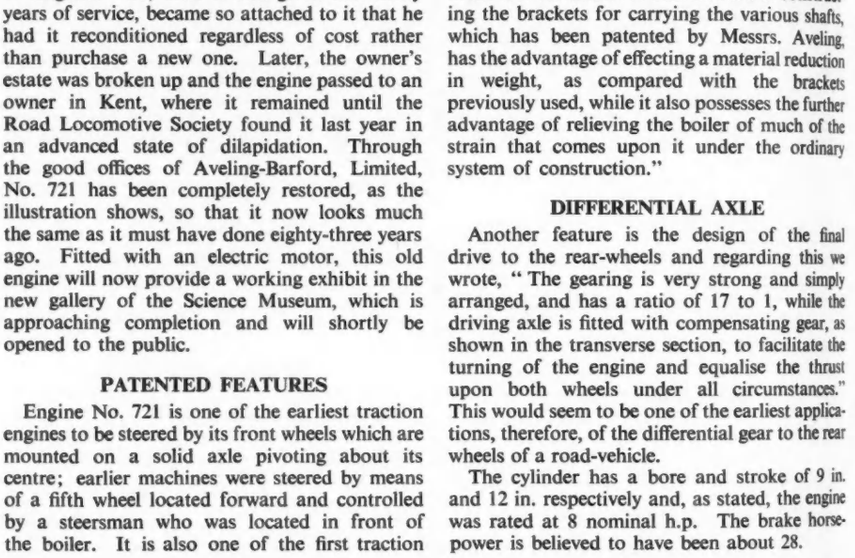
### PATENTED FEATURES

Engine No. 721 is one of the earliest traction engines to be steered by its front wheels which are mounted on a solid axle pivoting about its centre; earlier machines were steered by means of a fifth wheel located forward and controlled by a steersman who was located in front of the boiler. It is also one of the first traction engines to incorporate a patented method of supporting the crankshaft, and since the columns of ENGINEERING have seen the arrival and relegation of this type of traction engine, we quote from our issue of June 30, 1871 (p. 453, vol. xi). "Instead of the usual cumbersome brackets, the engine we illustrate has simply the side plates of the firebox extended upwards and backwards so as to carry bearings of the crank shaft, counter shaft, and driving axle, as shown in the side elevation . . . This method of constructing the brackets for carrying the various shafts, which has been patented by Messrs. Aveling, has the advantage of effecting a material reduction in weight, as compared with the brackets previously used, while it also possesses the further advantage of relieving the boiler of much of the strain that comes upon it under the ordinary system of construction."

### DIFFERENTIAL AXLE

Another feature is the design of the final drive to the rear-wheels and regarding this we wrote, "The gearing is very strong and simply arranged, and has a ratio of 17 to 1, while the driving axle is fitted with compensating gear, as shown in the transverse section, to facilitate the turning of the engine and equalise the thrust upon both wheels under all circumstances." This would seem to be one of the earliest applications, therefore, of the differential gear to the rear wheels of a road-vehicle.

The cylinder has a bore and stroke of 9 in. and 12 in. respectively and, as stated, the engine was rated at 8 nominal h.p. The brake horsepower is believed to have been about 28.



**The Aveling and Porter traction engine built in 1871, after being renovated by Aveling-Barford, Limited, ready for transporting to the Science Museum, London, to which it has been presented.**

*Labour Notes*

# EARNINGS IN FRONT OF LIVING COSTS

During the past six months, more than 70 claims for higher wages, involving well over four million employees, had been settled through the ordinary negotiating machinery, Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, told listeners, in a political broadcast last Saturday. He considered, therefore, that it was nonsense for some people to suggest that the country was in the midst of a great wave of strikes and unrest.

It should be made quite plain, indeed, that relations between employers, trade-union leaders and the Government remained frank and friendly. Further, there was no disagreement between them regarding the main objects which they sought to achieve, or about the necessity for maintaining good human relations right through the nation's industrial structure.

So far from deliberately causing industrial unrest, as had been dishonestly suggested in some quarters, the Government's policy had resulted in earnings running ahead of living costs, instead of chasing behind them.

The truth about the present industrial situation was that there was bound to be a period of tough industrial bargaining when the cost of living stopped rising and when the end of the seller's market made it impossible for employers any longer to add wage increases automatically to the cost of their products.

The Government welcomed the fact that the average earnings for men engaged in manufacturing industries were well over £9 10*s.* a week, and were anxious to see them go still higher, provided only that they were pushed up by increased efficiency and higher production. The most satisfactory means of obtaining more money, Mr. Watkinson suggested, was to think less about basic wage rates and more about production.

To find a successful solution to the new problems with which all sections of the community would be faced during the second half of this "turbulent, challenging" century, it would be necessary to engage in more team-work, and to absorb the ideas of high earnings linked to high output and of a lively planned economy. Trade unionists could do much to help by taking a full interest in the work of their local branches.

## POWER ENGINEERS DESIRE IMPROVED STATUS

For some time past, engineering operatives and technologists in the electricity-supply industry have been seeking a higher status, through their trade union, the Electrical Power Engineers' Association. The men are seeking to effect a substantial improvement in their position, in relation to other employees in the industry, and are hoping to obtain considerable advances in their salaries.

The Association, which has requested an interview with representatives of the British Electricity Authority, in order to push forward the men's demands, includes in its ranks all grades up to that of power-station superintendent, and has intimated that, if its request for discussion is declined, it will serve notice on the Authority to terminate the existing agreements of its members.

The Association's demands were due to be considered by the Authority at some length at its meeting yesterday. The Association is a registered trade union and is affiliated to the Trades Union Congress and to the Scottish Trades Union Congress.

## STRIKE IN ELECTRICITY-SUPPLY INDUSTRY CONTINUED

There was no sign during the past week-end of any improvement in the strike situation in the electricity-supply industry. Members of the union concerned, the Electrical Trades Union, duly began their one-week protest strike at Liverpool on February 1 and a statement issued by that body last Friday declared that the stoppage had been entirely successful. The strikers, it was added, would report for work in the usual way on Monday morning.

Reference was made in the statement, without any apparent sign of regret, to the fact that the number of members of the union who have taken strike action of one sort or another since January 11, was in addition to the "1,800 other workers who have been involved in indefinite strike action for the past three to four weeks."

Last Friday, at the termination of the week's inactivity, a procession of trade unionists demanding higher wages, took place through the streets of Liverpool, in which it was estimated that some 12 hundred workpeople took part. Those taking part in the demonstration are reported to have included representatives of the National Federation of Building Trade Operatives and of the Merseyside district of the Confederation of Shipbuilding and Engineering Unionsl as well as representatives of the Electrical Trades Union.

## STRIKE PAY FOR NON-UNIONISTS

The Manchester district was the area chosen for the third of the one-week strikes organised by the Electrical Trades Union in protest against the refusal of the employers' organisation, the National Federated Electrical Association, to concede wage increases to men employed in the electricity-supply industry. It is understood that the advances desired by the union are 3*d.* an hour more for men in the London area and 2½*d.* an hour more for men working in the provinces.

It was confidently expected by the union last week that some 1,400 members, employed by various firms of contractors in the Manchester district, would cease work, but estimates on Monday varied considerably as to the number of workpeople who had, in fact, joined in the week's demonstration.

A statement issued by the union's local office in Manchester informed members that strike pay would be granted, not only to operatives belonging to that organisation, but also to non-unionists who took part in the one-week strike, and it requested that that offer should be made known as widely as possible.

Non-unionists, however, who ceased work and applied for strike benefits would, it was pointed out, be expected to apply for membership of the union.

On their part, the employers in the Manchester district, not unnaturally, perhaps, have attributed the union's action in this connection to its disappointment at the lack of support, in the area, for the recent 24-hour national stoppage.

In all the recent strikes, members of the union working for firms who have concluded agreements with it, to pay wages in excess of current basic rates, have been excluded from taking strike action.

## EQUAL PAY DEPUTATION TO CHANCELLOR OF THE EXCHEQUER

Agitation continues to be made for the early introduction of equal pay for women. Introducing a deputation on this subject to Mr. R. A. Butler, the Chancellor of the Exchequer, on February 5, Mrs. Cazalet-Keir, chairman of the equal pay campaign committee, stated that the urgency for making a beginning with equal pay to employees in the Civil Service, local government, and the teaching profession, was considerably strengthened by the increasing number of anomalies which were arising between the payments made to men and women in these services.

Parliament had declared itself in favour of the principle of equal pay for women at least 35 years ago and it had gone on reaffirming that principle ever since. The time had surely come, Mrs. Cazalet-Keir suggested, for the matter to be translated from the sphere of accepted principle to the realm of accomplished fact.

On behalf of the National Association of Women Civil Servants, it was contended by Miss H. C. Hart, the Association's secretary, that the cost of introducing the reform in the Civil Service would amount to little more than £32 million a year. Undoubtedly, a large proportion of this sum would return to the Exchequer in the form of taxation.

The granting of this concession in the Civil Service should do much to stimulate competition there, and should be the means of increasing outputs all round.

Subsequently, the deputation stated that they were firmly opposed to any gradual approach to the problem. They were in favour of the early equalisation of pay throughout the public services, wherever the same work was performed equally by men and women, and where the two sexes were interchangeable.

In his reply, the Chancellor referred to the very great burden of taxation at present being borne by people in the United Kingdom. The country was, in fact, meeting a record peace-time expenditure in respect of defence, education and the social services. He promised, however, to give the most careful consideration to the arguments put forward by the deputation.

The delegates who were present at the discussion numbered over 50 and the deputation was stated to be one of the most comprehensive so far arranged by the committee.

## INDUSTRIAL DISPUTES IN 1953

Statistics recently issued by the Ministry of Labour and National Service show that stoppages of work, arising from industrial disputes in the United Kingdom, during last year, resulted in a loss of some 2,169,000 working days at the establishments where the stoppages occurred. About 6 per cent. of the total population engaged in civil employment was involved in these stoppages, and the loss of time for each employee concerned averaged about two working days during the year. In comparison, the total number of days lost during 1952 numbered about 1,792,000.

The aggregate number of workpeople involved in stoppages which took place during 1953 was about 1,352,700, of whom fewer than about four thousand were concerned in disputes that had begun during the previous year and were continued into 1953. Of the 1,352,700 persons involved in all stoppages in progress in 1953, only some 40,900 were thrown out of work at the establishments where the strikes occurred, without themselves being parties to the disputes. The total number of workpeople involved in all stoppages in progress during 1952 was about 416,000.

Disputes reported to the Ministry as commencing in 1953 numbered 1,746, compared with the 1,714 stoppages which began in the previous year.

The largest single stoppage arising from an industrial dispute during 1953 was a one-day token stoppage in December. This followed the rejection of a wage claim for a 15 per cent. increase in the engineering industry.

# NOTICES OF MEETINGS

### Association of Supervising Electrical Engineers

LONDON
"Engineer in Management," by H. Bainbridge. 2 Savoy-hill, W.C.2. Tues., Feb. 16, 6.30 p.m.
"Electric Water Heating," by L. L. Hughes. South-West London Branch. 32 Worple-street, Wimbledon, S.W.18. Wed., Feb. 17, 8.15 p.m.

BOURNEMOUTH
"Electronic Control," by G. L. G. Jeans. Grand Hotel, Firvale-road, Bournemouth. Mon., Feb. 15, 8.15 p.m.

### British Institution of Radio Engineers

LONDON
"Electronics in Film Making," by W. D. Kemp and B. R. Greenhead. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Feb. 17, 6.30 p.m.

### Chemical Society

EDINBURGH
"Recent Progress in the Study of Metallic Corrosion," by Dr. W. H. J. Vernon. North British Station Hotel, Edinburgh. Thurs., Feb. 18, 8 p.m.

LEEDS
"Corrosion Theory in Practice," by Dr. T. P. Hoar. The University, Leeds. Mon., Feb. 15, 6.30 p.m.

### Diesel Engine Users Association

LONDON
"Diesel Engines in Agriculture," R. M. Ogorkiewicz. Caxton Hall, Victoria-street, S.W.1. Thurs., Feb. 18, 2.30 p.m.

### Incorporated Plant Engineers

BLACKBURN
"Fire Protection for Industrial Buildings," by A. Jackson. Grosvenor Hotel, Lord-street, Blackburn. Thurs., Feb. 18, 7.30 p.m.

BRISTOL
"The Generation of Industrial Power from Process Steam," by Dr. E. G. Ritchie. Western Branch. Grand Hotel, Bristol. Wed., Feb. 17, 7.15 p.m.

GLASGOW
"Industrial Lighting," by F. H. Fielder. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Wed., Feb. 17, 7 p.m.

### Institute of British Foundrymen

BRISTOL
"Steel-Foundry Process Control," by S. L. Finch. Bristol and West of England Branch. Grand Hotel, Bristol. Sat., Feb. 20, 3 p.m.

### Institute of Fuel

CHESTER
"Underground Gasification," by C. A. Masterman. North-Western Section. Grosvenor Hotel, Chester. Wed., Feb. 17, 7.30 p.m.

### Institute of Refrigeration

LONDON
"Modern Methods of Oxygen Production," by A. M. Clark. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Tues., Feb. 16, 5.30 p.m.

### Institute of Road Transport Engineers

LONDON
"Lighting for Commercial Vehicles and Its Contribution to Road Safety," by Dr. J. H. Nelson. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Feb. 18, 6.30 p.m.

LEEDS
"Paint: Synthetic Resin Finishes and Wet-on-Wet Spraying," by E. C. Wright. Yorkshire Centre. Hotel Metropole, King-street, Leeds, 1. Thurs., Feb. 18, 7.30 p.m.

### Institution of British Agricultural Engineers

LONDON
"Mechanisation of Bracken Eradication," by G. Henderson. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Feb. 16, 2.15 p.m.

### Institution of Civil Engineers

LONDON
"History and Construction of the Foundations of the Asia Insurance Building, Singapore," by W. J. R. Nowson. Tues., Feb. 16, 5.30 p.m.

LOUGHBOROUGH
"Railway Engineering in the Midlands, 1948-1953," by C. W. King and F. Turton. Midlands Association. Loughborough College, Loughborough. Wed., Feb. 17, 7 p.m.

MANCHESTER
"Plant for the Construction and Maintenance of Highways," by R. R. W. Grigson. Dugald Clerk Lecture. North-Western Association. Engineers' Club, Manchester. Thurs., Feb. 18, 6.30 p.m.

### Institution of Electrical Engineers

LONDON
"The Teaching of the Subject of Insulating Materials." Discussion, opened by Dr. Willis Jackson. Education Discussion Circle. Mon., Feb. 15, 6 p.m.
"Electro-Heat and Prosperity." Faraday Lecture, by O. W. Humphreys. Central Hall, Westminster, S.W.1. Admission by ticket only. Tues., Feb. 16, 6 p.m.
"Electronic Motor Control," by A. O. Dalton; "Arc-Quenching Circuits," by B. H. Stonehouse; and "A Survey of the Principles of the Contact Rectifier," by D. R. Smith. Utilization Section. Thurs., Feb. 18, 5.30 p.m.

ARBORFIELD, BERKSHIRE
"Development of Electrical Aids in Anti-Aircraft Gunnery," by D. H. A. Huddart. London Students' Section. R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield. Tues., Feb. 16, 6.30 p.m.

KETTERING
"Overhead Distribution," by H. W. Grimmitt. East Midland Centre. George Hotel, Kettering. Thurs., Feb. 18, 7.30 p.m.

LIVERPOOL
"Plan for Electricity," by G. K. Alston. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Feb. 15, 6.30 p.m.

NOTTINGHAM
"Design Features of Certain British Power Stations," by S. D. Whetman and A. E. Powell. East Midland Centre. Gas Department's Showrooms, Nottingham. Tues., Feb. 16, 6.30 p.m.

SOUTHAMPTON
"Electro-Heat and Prosperity." Faraday Lecture. Southern Centre. Guildhall, Southampton. Thurs., Feb. 18, 6.30 p.m.

### Institution of Mechanical Engineers

LONDON
"Production and the Mechanical Engineer," by L. H. Leedham. Industrial Administration and Production Engineering Group. Fri., Feb. 19, 5.30 p.m.

BEDFORD
Repetition of Presidential Address, by A. Roebuck. Eastern Branch. Dujon Restaurant, Bedford. Tues., Feb. 16, 7.30 p.m.

BIRMINGHAM
"High-Temperature Turbine Machinery for Marine Propulsion." Thomas Lowe Gray Lecture, by Dr. T. W. F. Brown. Midland Branch. James Watt Memorial Institute, Birmingham. Thurs., Feb. 18, 6 p.m.

BRISTOL
"Relaxation Methods: A Retrospect." Thomas Hawksley Lecture, by Sir Richard Southwell. Western Branch. Grand Hotel, Bristol. Tues., Feb. 16, 7 p.m.

GLASGOW
"Automobile Engineering," by A. Kemp. Scottish A.D. Centre. 39 Elmbank-crescent, Glasgow, C.2. Mon., Feb. 15, 7.30 p.m.

HULL
"Airships," by Lord Ventry. Yorkshire Branch. Station Hotel, Hull. Wed., Feb. 17, 7.15 p.m.

LEEDS
"Combustion in Compression-Ignition Oil Engines," by Professor S. J. Davies. North-Eastern A.D. Centre. The University, Leeds. Wed., Feb. 17, 7.30 p.m.

LIVERPOOL
"High-Temperature Turbine Machinery for Marine Propulsion." Thomas Lowe Gray Lecture, by Dr. T. W. F. Brown. North-Western Branch. 9 The Temple, 24 Dale-street, Liverpool. Wed., Feb. 17, 6 p.m.

MANCHESTER
"An Investigation of Fretting Corrosion," by Dr. K. H. R. Wright. North-Western Branch. Engineers' Club, Manchester. Thurs., Feb. 18, 6.45 p.m.

### Institution of Mining and Metallurgy

LONDON
Discussion on "Present-Day Meaning Given to the Term 'Ore';" and "Production of Asbestos in South Africa," by W. E. Sinclair. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Thurs., Feb. 18, 5 p.m.

### Institution of Production Engineers

BIRMINGHAM
"Glass Fibres," by J. B. Mitford. James Watt Memorial Institute, Birmingham. Wed., Feb. 17, 7 p.m.

EDINBURGH
"Electronics in Industry," by G. Horsfall. North British Station Hotel, Edinburgh. Wed., Feb. 17, 7.30 p.m.

GLASGOW
"Spheroidal-Graphite Cast Iron," by Dr. A. B. Everest. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 18, 7.30 p.m.

HALIFAX
"Foundry Mechanisation and Improved Methods of Production," by G. W. Nicholls. White Swan Hotel, Halifax. Tues., Feb. 16, 7.15 p.m.

NEWCASTLE-UPON-TYNE
"Horizontal Boring," by R. Hallam. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 15, 7 p.m.

OXFORD
"Cold Forming of Light Alloys," by D. A. Barlow. Town Hall, Oxford. Tues., Feb. 16, 7.15 p.m.

YARMOUTH
Film Evening. Norwich Section. Yarmouth Technical Institute, Yarmouth. Fri., Feb. 19, 7.30 p.m.

### Institution of the Rubber Industry

LEICESTER
"Rubber and Plastics in the Home," by Robert Cantor. Bell Hotel, Leicester. Thurs., Feb. 18, 7.30 p.m.

LIVERPOOL
"Use of Rubber in Aircraft," by W. J. Bloomfield and E. W. Russell. Electricity Supply Showrooms, Whitechapel, Liverpool. Mon., Feb. 15, 7 p.m.

### Institution of Structural Engineers

LEEDS
"Driving and Testing of Piles," by H. D. Morgan. Yorkshire Branch. Great Northern Hotel, Leeds. Wed., Feb. 17, 6.30 p.m.

PLYMOUTH
"Structural Engineering at Abbey Works, Margam," by A. V. R. Hooker. South-Western Counties Branch. Duke of Cornwall Hotel, Plymouth. Fri., Feb. 19, 7 p.m.

### Institution of Water Engineers

LONDON
"Some Examples of Hydraulic Scale Models," by Dr. J. Allen. Joint Meetings of South-Eastern and Land Drainage Sections. Institution of Civil Engineers, Great George-street, S.W.1. Fri., Feb. 19, 2.30 p.m.

### Institution of Works Managers

STOCKTON-ON-TEES
Film Evening. Tees-Side Branch. Vane Arms Hotel, Stockton-on-Tees. Wed., Feb. 17, 7.30 p.m.

### Junior Institution of Engineers

LONDON
"Design and Construction of Modern Gas Appliances," by Lieut.-Col. H. S. Walter. Townsend House, Greycoat-place, S.W.1. Fri., Feb. 19, 7 p.m.

### Manchester Association of Engineers

MANCHESTER
"Sound Absorption," by F. G. Ewing. Engineers' Club, Manchester. Fri., Feb. 19, 6.45 p.m.

### Reinforced Concrete Association

LONDON
"Recent Developments in Vacuum Concrete," by Major L. A. Leech. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Wed., Feb. 17, 6 p.m.

### Royal Aeronautical Society

LONDON
"Helicopter Research," by F. J. O'Hara. Section Lecture. Joint Meeting with the Helicopter Association. Thurs., Feb. 18, 7 p.m.

### Royal Meteorological Society

LONDON
Various short papers. Wed., Feb. 17, 5 p.m.

### The Royal Society

LONDON
"Decomposition of Solid Azides by Electron Bombardment," by J. M. Groocock and F. C. Tompkins. Thurs., Feb. 18, 4.30 p.m.

### Sheffield Metallurgical Association

SHEFFIELD
"Analytical Chemistry of Boron," by H. G. Short. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Feb. 16, 7 p.m.

### Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"The Future of Steel Melting," by Professor W. M. Thring. Mon., Feb. 15, 7.30 p.m.

### Society of Chemical Industry

LONDON
"Use of Non-Ferrous Metals in Domestic Water Supply," by H. S. Campbell. Corrosion Group. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Thurs., Feb. 18, 6 p.m.

### West of Scotland Iron and Steel Institute

GLASGOW
"Notch Ductility of Quenched and Tempered Steels," by S. Downs; and "Vertical Rolling Mills," by J. A. Kilby and G. A. V. Russell. Fri., Feb. 19, 6.45 p.m.

### Women's Engineering Society

LONDON
"The Manufacture of Fashion Jewellery and Accessories," by Miss D. Pile. Wed., Feb. 17, 7 p.m.

**The address of the headquarters of each Institution is given in the following list. Meetings held in the headquarters town are held at this address unless otherwise stated.** Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1.
Chemical Society, Burlington House, Piccadilly, London, W.1.
Diesel Engine Users Association, 56 Victoria-street, London, S.W.1.
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham.
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3.
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1.
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3.
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1.
Institution of British Agricultural Engineers, 24 Portland-place, London, W.1.
Institution of Civil Engineers, Great George-street, London, S.W.1.
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2.
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1.
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2.
Institution of Production Engineers, 36 Portman-square, London, W.1.
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1.
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1.
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2.
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1.
Manchester Association of Engineers, 20 Booth-street, Manchester, 2.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1.
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7.
Royal Society, Burlington House, Piccadilly, London, W.1.
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7.
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield, 1.
Society of Chemical Industry, 56 Victoria-street, London, S.W.1.
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2.
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1.